BIOPHILIC DESIGN: MORE THAN JUST PLANTS

EXAMINING THE STATUS QUO AND IDENTIFYING BARRIERS TO A DIVERSE PRACTICE

A Thesis

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ABSTRACT

A majority of the population now lives in urban environments and spends 90% of their time indoors, with little access to nature. This isolation has led to increased mental and physical health problems. Biophilic design is a solution to some of these issues, however, its use in practice is limited. This study aims to examine the current practice of biophilic design and identify barriers to implementation through semi-structured interviews with industry professionals. Six categories of barriers were identified which can be addressed through education, a consolidation of resources, and creating a clear value proposition through the introduction of a new key stakeholder: a design researcher. This thesis examined the current state of biophilic design, barriers to use, and steps to move forward while confirming that semi-structured interviews with three groups of industry professionals is a useful tool to determine barriers to entry for new designs in the built environment.

BIOGRAPHICAL SKETCH

Julie Gordonson was born in Jericho, NY. After completing four years at Syosset High School, she went on to attend Cornell University in 2012. She studied Design and Environmental Analysis with a minor in Environmental Science and Sustainability at the College of Human Ecology and received her Bachelor of Science in 2016. In 2017, she decided to return to Cornell to earn her master's degree in Human-Environment Relations with a concentration in Sustainable Design Studies at the Cornell Graduate School. She hopes to bring her passion for sustainable design into her next chapter in the professional design field.

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PREFACE

Before this thesis paper unfolds before you, I am going to ask you to engage in a quick exercise for me. Close your eyes and imagine a place that makes you feel calm and relaxed, creative and energized. The place in your mind is one that relaxes and calms you, while simultaneously energizes you and gets the creative juices flowing. Can you picture this place?

You may be surprised to learn that, if you are like 90% of the population, the odds are that you were imagining a place in nature. Most of you were specifically thinking of a place near a body of water, like laying on a beach, relaxing on a boat, sitting by a waterfall, or hiking by a river. Others were perhaps imagining standing on the top of a mountain staring into the abyss, climbing over rocks in the desert, or even just exploring your own backyard. The point is, none of you were thinking about a workplace, a school, or a hospital. None of you were thinking about the places where we actually need to feel these emotions to be productive, whether it be working, learning, or healing.

That is what this thesis project is about, bringing elements from the natural world that can inspire, restore, and connect us into the places where we need them most. If we are lucky, we can achieve this while simultaneously engendering a stronger connection to nature and decreasing the amount of stress we feel in our daily lives. If you are interested to learn more, please read on, but I suggest you find a nice spot outside to do so.

1. Introduction

In recent years, the world has become more urbanized (United Nations, 2014). The majority of the global population now lives in cities and people spend 90% of their time indoors (Environmental Protection Agency [EPA], 2017; United Nations, 2014). This migration to urban areas has led to an isolation from nature that is apparent in most global cities (Turner, Nakamura, Dinetti, 2004). Due to this disconnect from nature, a number of deleterious outcomes have emerged, including stress, fatigue, decreases in satisfaction, and increases in physical and mental illness (Browning, Ryan, & Clancy, 2014).

There has been a growing trend in the building industry towards sustainable, highly efficient buildings in recent years. Driven by the current state of environmental degradation and finite natural resources, buildings are utilizing innovative technology to become less energy intensive. While sustainable design emphasizes a connection to nature in theory to promote environmental attitudes, in practice, this connection is usually limited due to minimal access to nature in urban places. The goal of biophilic design is to re-establish this connection to nature through design (Kellert, Heerwagen, Mador, 2008). In doing so, the human condition of the environments we live in will be improved, promoting positive health outcomes, increasing satisfaction and productivity, and creating restorative spaces (Kellert et al., 2008).

While there is an extensive amount of theories, research, and resources on biophilic design, the practice of it is fairly limited and misunderstood. This gap, between theory and practice, must be explored further to understand why biophilic design is not being utilized in its full potential. This thesis aims to identify barriers to

high quality biophilic design interventions and understand what practitioners need to successfully implement it.

1.1 Literature Review

The term biophilia was first used in 1964 by Erich Fromm, when discussing the essence of man (Fromm, 1964). In it, he notes that biophilia is the love of life and living things, which is a tendency that humans constantly seek (Fromm, 1964). The idea was confirmed and further explored by Edward O. Wilson who posited the biophilia hypothesis, an extension of this idea that states humans have an innate, biologically based desire to focus on and connect with life and lifelike processes, such as nature and ecosystems (Kellert & Wilson, 1993; Wilson, 1984). This innate drive stems from our evolutionary past, as humans as a species evolved in nature for over two million years (Coolidge & Wynn, 2018; Kellert & Wilson, 1993). It was not until 10,000 years ago that humans transitioned from a nomadic way of life to a more sedentary one, paving the way for civilization and the lifestyle that we know today (Coolidge & Wynn, 2018). For millions of years, accounting for almost 99% of our time on Earth, humans have lived in and become accustomed to nature (Kellert & Wilson, 1993). The brain evolved in this natural setting, not the one that we live in today, and thus, some preferences, motivations, and behavioral responses revolve around nature and natural processes (Hinds & Sparks, 2011; Kellert & Wilson, 1993; Ulrich, 1993). These have not been forgotten in the transition to modern society and, in fact, provide a plethora of beneficial consequences that we can reap, if we design

our environments, both indoors and outdoors, to evoke this connection to our natural past.

Evolutionary Precedents

A key aspect of the biophilia hypothesis is that affiliating with nature is a biologically engrained behavior (Wilson, 1984). For this to be the case, biophilia, at some point in human evolution, must have provided a competitive advantage for survival (Kellert & Wilson, 1993). In fact, if a specific phenotype of our evolutionary ancestor affiliated with specific forms of nature, and this garnered more fitness than a different phenotype, they would be more likely to survive and have offspring that exhibit the same tendencies (Kellert & Wilson, 1993; Ulrich, 1993). Over time, this would have led to a set of universal preferences for specific landscapes and habitats that generated this competitive advantage (Browning et al., 2014; Kellert & Wilson, 1993). It should be noted that biophilia is not the only evolutionary adaptation; a series of biophobias also exist, which can be defined as fear responses to specific environments and animals that are easily learned and remembered due to their adaptive significance (Ulrich, 1993). For example, a universal fear and fascination with snakes is cross-culturally significant (Ulrich, 1993; Wilson, 1984).

The evidence on adaptational biophilia points to the landscape that homo sapiens inhabited: the savanna. This environment offered specific elements that led to human survival, such as food, water, and security. Multiple studies have shown that humans prefer landscapes that exhibit characteristics of savannas, including spatial openness, small clusters of trees, and uniform grass (Falk & Balling, 2009; Hinds &

Sparks, 2011; Orians & Heerwagen, 1992). Preference increases when water is accessible as well (Hinds & Sparks, 2011; White et al., 2010). There are many reasons why humans may prefer these landscapes, such as a direct or indirect signal for water and food in lush, green areas and security from predators, as there is less space to hide (Browning et al., 2014). Other preferences include prospect-refuge, a combination of environments that allow one to see far beyond where they are and alternately provide space for shelter and security (Heerwagen & Orians, 1993). Mystery, coherence, complexity, and legibility in environments are also spatial elements that humans prefer (Kaplan, 1987). These specific characteristics garnered survival for our ancestors, which led to adaptions that are still present today.

Outcomes of Biophilia: Physiological, Psychological, and Cognitive Function

There are three major categories of benefits that have been found when humans are exposed to nature or evocations of nature: physiological benefits, psychological benefits, and cognitive functioning benefits (Ulrich, 1993). Physiologically, it has been shown that being in nature reduces the stress response, effectively decreasing blood pressure and cortisol levels in the body (Ulrich, 1993; Ulrich et al., 1991). Physiologically, these positive outcomes are especially important over time, as chronic stress can lead to many negative health outcomes like cardiovascular disease, obesity, and mental illness (Hartig, Mitchell, de Vries, & Frumkin, 2014). In a similar vein, studies have shown that access to natural views reduces healing time in hospitals and patients report less pain (Velarde, Fry, & Tveit, 2007). In prisons, a view of nature was correlated with less visits to the infirmary

(Velarde et al., 2007). These studies provide some of the grounding for how access to nature improves physiological functioning in regard to health and healing.

From a psychological perspective, access to nature has been shown to quickly improve mood and reduce symptoms of mental illness (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2008; Ulrich, 1993). According to Stress Reduction Theory, nature creates a response in the parasympathetic nervous system that mitigates the stress response, as noted in the previous paragraph (Ulrich, 1993; Ulrich et al., 1991). However, this response also has been shown to improve affect, reduce occurrences of mental distress, and improve overall psychological well-being (Hartig et al., 2014; Mayer et al., 2008; Ulrich, 1993). In general, exposure to nature has been correlated with happiness, which has been classified in both hedonistic and eudemonic terms (Capaldi, Ropko, & Zelenski, 2014; Hinds & Sparks, 2011). Individuals with high nature connectedness tend to have higher ratings of vitality, positive affect, and life satisfaction (Capaldi, Ropko, & Zelenski, 2014). Additionally, natural views in the workspace have been correlated with higher life satisfaction ratings in employees than those without views of nature (Kaplan, 1993). Beyond just improving mood, experiences in nature have been associated with less rumination, anxiety, and negative mood, which are all symptoms of mental illness and depression (Bratman, Daily, Levy, & Gross, 2015). There is also an association between positive affect and creativity, as people who report better moods score higher on the remote associates test and other creativity measures than their less happy counterparts (Isen, Daubman, & Nowicki, (1987).

Lastly, exposure to nature, whether real or artificial, has been shown to improve cognitive function (Hartig et al., 2014; Kaplan & Kaplan, 1989; Velarde et al., 2007). Both short and long-term exposure to nature has been associated with the restoration of cognitive resources that can be drained during normal day to day life (Bratman et al., 2015; de Kort, Meijnders, Sponselee, & IJsselsteijn, 2006; Kjellgren & Buhrkall, 2010; Lee, Williams, Sergeant, Williams, & Johnson, 2015). These studies support Attention Restoration Theory (ART), which states that directed attention, which is limited and easily drained, can be restored by engaging involuntary attention, which is simply captured by certain stimuli (Kaplan & Kaplan, 1989). These stimuli must be fascinating, create a sense of being away, provide person environment fit, and have a large extent to effortlessly capture attention and restore depleted attentional resources (Ohly et al., 2016). Nature and evocations of nature happen to meet all these requirements, and thus have been known to restore attention in as little as five minutes (Kaplan, 1995). While exposure to true nature is more effective at restoring cognitive resources than artificial nature, there is still an improvement in cognitive resources seen when exposed to artificial nature (de Kort et al., 2006; Kjellgren & Buhrkall, 2010).

In addition to the benefits to individuals discussed above, exposure to nature can also engender a connection to it, which is often believed to be a mediator towards greater environmental attitudes (Capaldi, Dopko, & Zelenski, 2014; Nisbet, Zelenski, & Murphy, 2009; Wells & Lekies, 2006). In a time where environmental quality is declining, this outcome may prove to have large benefits to society by creating a population that will be stewards to the Earth.

Current Societal Trends

The environments that humans evolved in are in direct contrast to the environments that they live in today. A majority of the population now lives in cities, a trend that will continue to grow in future years, as it is projected that by 2050, two-thirds of the global population will inhabit urban environments (United Nations, 2014). Additionally, people in the United States spend, on average, 90% of their days indoors, while the average American working adult spends 7.8 hours a day working during the work week (EPA, 2017; U.S. Bureau of Labor Statistics, 2014). This means that most of the time, humans have very little interaction with the natural world. Deleterious effects are beginning to emerge from this lack of interaction (Browning et al., 2014; Capaldi, Dopko, & Zelenski, 2014). Stress, burnout, and fatigue have become typical in American office worker and negatively impact the quality and efficiency of completed work (Brewer & Shapard, 2004; Sonnentag, 2015). Health and wellness issues have been brought to the forefront of our society, with the obesity epidemic continuing to grow and reported mental illness rising in the United States (Hales, Carroll, Fryar, & Ogden, 2017; Substance Abuse and Mental Health Services Administration, 2017). Additionally, absenteeism, when employees miss work due to illness or other circumstances, and presenteeism, a phenomenon when employees come to the office but are not focused enough to do work, are rising trends (Demerouti, Le Blanc, Bakker, Schaufeli, & Hox, 2009; Human Spaces, 2015).

Biophilic Design: Background, History, and Value

While some of this data may be attributed to cultural and social norms, environmental factors have been proven to influence these outcomes as well. The environment can both help and hinder wellness, productivity, stress, and satisfaction (Centers for Disease Control and Prevention, 2015; Danielsson & Bodin, 2008; Horr et al., 2016; Perdue, Stone, & Gostin, 2003; Ulrich, 1991). Biophilic design is a field that has been gaining traction to mitigate these negative outcomes (Kellert et al., 2008). Founded on the theory of biophilia, biophilic design is an ethos dedicated to evoking a sustained connection to nature through well-planned design elements (Kellert et al., 2008; Kellert & Wilson, 1993). A successful biophilic design will not only evoke a connection to nature, but also create a sense of place and seamlessly integrate natural systems and processes into the design (Kellert & Calabrese, 2015; Kellert et al., 2008).

The idea of biophilic design is not something new; it is about tapping into an ethos that has been engrained in us as a species since we first appeared on Earth (Browning et al., 2014; Salingaros & Madsen, 2008). Biophilic design is about connecting to what we already know, drawing upon the thread that has been prevalent throughout all architectural and design history, that nature is good for us and thus, we ought to create more opportunity to engage with it (Browning et al., 2014; Kellert et al., 2008). Humans have always valued nature in their built world (Browning et al., 2014; Kellert et al., 2008). Consider the attraction to the hanging gardens of Babylon, the pervasive bonsai in Japan, the diversity of Gothic and Victorian ornament, the inspiration of Art Nouveau, and the allure of Frank Lloyd Wright's organic architecture (Browning et al., 2014; Salingaros & Madsen, 2008). However, modern

and urban design has created a stark disconnect between the built and natural world, isolating people from nature (Salingaros & Madsen, 2008). Despite this division, humans habituate to the built world, unaware of the consequences (Goldhagen, 2017). Meanwhile, biophilic design, which is hoping to repair this division, is slowly gaining ground. This type of design is looking to improve the built environment and create spaces where people feel happy, inspired, restored, creative, and productive (Browning et al., 2014; Kellert & Calabrese, 2015; Kellert et al., 2008). Various experts have created different biophilic design frameworks that fall into principles, elements, patterns, experiences, and categories (Browning et al., 2014; Kellert & Calabrese, 2015; Kellert et al., 2008). Despite the varying organization and language, the original 72 principles of biophilic design and the 14 patterns of biophilic design fall mainly into three, agreed upon categories: direct experience of nature, indirect experience of nature, and spatial/place-based experiences (Browning et al., 2014; Kellert & Calabrese, 2015; Kellert et al., 2008). For the purposes of this thesis, the terms biophilic element, biophilic pattern, and biophilic strategy will be used interchangeably as a mode of incorporating a specific type of biophilic design into a space.

Direct Experience of Nature

The first category of these biophilic elements is a direct experience of nature, which is sometimes known as nature in space (Browning et al., 2014; Kellert & Calabrese, 2015). This category is focused on an actual physical connection to nature, experienced through the five senses, by bringing nature into a space (Browning et al.,

2014; Kellert & Calabrese, 2015). The exact definition of this category varies, as some frameworks only consider naturally occurring elements to be direct and others expand it to include artificial nature as well (Browning et al., 2014; Kellert & Calabrese, 2015; Kellert et al., 2008). For the purposes of this literature review, direct experience of nature will include artificial natural that is physically in the space, as it broadens the type of designs that design professionals can include in urban environments because it is increasingly difficult to provide access to nature in its true form. This can be achieved through visuals elements, such as access to windows with views of nature, indoor plants, and daylight, as well as non-visual elements like water features that produce sounds, thermal variability, and natural scents (Browning et al., 2014; Kellert & Calabrese, 2015; Kellert et al., 2008). Additionally, creating a connection to natural systems and incorporating non-rhythmic sensory stimuli that suggest ephemeral changes in the space are important to this category (Browning et al., 2014).

Indirect Experience of Nature

The second category of biophilic design involves an indirect connection to nature (Kellert & Calabrese, 2015). This category is also sometimes called natural analogues (Browning et al., 2014). Focusing on evoking a sense of nature, indirect experiences revolve around symbolic representations of nature. Design elements in this category include natural colors, biomorphic forms, organic shapes, biomimicry, sequences found in nature, patterns, textures, and visual representations of nature (Browning et al., 2014; Kellert & Calabrese, 2015; Kellert et al., 2008). An example of an indirect connection to nature would be a picture of a plant, or a projected image

of a plant, rather than placing a physical plant in the space. Other examples include use of natural materials like wood and stone, carpets with natural patterns, or biomorphic feature walls.

Spatial/Place-Based Experiences

The final category of biophilic design involves spatial and place-based experiences, which is also known as nature of the space (Browning et al., 2014; Kellert & Calabrese, 2015; Kellert et al., 2008). This category of biophilic design elements taps into spatial preferences that humans have evolved to have and engenders a connection to place through its design. Examples of evolved spatial preferences include prospect and refuge, two spatial preferences that balance each other, with prospect providing the ability to see beyond usual surroundings and refuge creating a small and safe space (Browning et al., 2014; Kellert & Calabrese, 2015; Kellert et al., 2008). Other evolved preferences include a sense of mystery in space, completed by creating spaces that are designed to leave more to the imagination, by obscuring all the information of the space through curves and corners (Browning et al., 2014; Kellert & Calabrese, 2015; Kellert et al., 2008). Another design principle that falls into this category, although sometimes it is discussed in the indirect experience of nature due to its fractal geometry nature, is ordered complexity (Kellert & Calabrese, 2015). This refers to a complex environment that is slightly ordered to prevent a sense of chaos emerging, but provides enough information density that stimulates and draws us in. Other important spatial experiences include transitions between spaces, whether that be between an indoor and outdoor space, or the interior environment (Kellert &

Calabrese, 2015). Lastly, peril is a design element that provides a feeling of threat in a controlled environment, which excites and stimulates users (Browning et al., 2014; Kellert & Calabrese, 2015; Kellert et al., 2008). Examples of peril may include cantilevered designs, floating stairs, or a stone walking path through water.

Outcomes of Biophilic Design

Similar to the outcomes of biophilia, biophilic design interventions have also been proven to enhance physiological functioning through a reduced stress response, improve mood and psychological well-being, and augment cognitive performance (Browning et al., 2014; Söderlund & Newman, 2015). Specific elements have been correlated to each of these outcomes, for example, dynamic light has been correlated with improved circadian rhythm, enhancing sleep while reducing stress, whereas spaces that are classified as refuge have been shown to improve cognitive performance (Browning et al., 2014). Thus, all biophilic design interventions will not have the same effect. In fact, to reap the largest benefit from biophilic design, combinations of elements that have been shown to influence a specific desired outcome should be implemented together, in a decisive way (Browning et al., 2014). In Figure 1.1, an overview of how each element leads to specific beneficial outcomes is shown, as well as the rigor of the research supporting these claims.

Limitations of Biophilic Design Research

It should be noted that some of these outcomes may be mutually exclusive. For example, the literature regarding plants and indoor air quality has noted that indoor

plants improve affect, but they may actually decrease productivity (Larson, Adams, Deal, Kweon, & Tyler, 1998). Additionally, the effects of combinations of biophilic elements has yet to be explored (Gillis & Gatersleben, 2015). Thus, it is important to determine which outcomes are desired in a specific space and incorporate biophilic design elements accordingly. Additionally, some of these elements have been extensively studied, like the effect of light and views to nature, where others have only just begun to be explored, like how materials and forms influence human psychology and physiology (Gillis & Gatersleben, 2015). There is still more research that must be conducted to prove causality between biophilic design elements and outcomes.

BIOPHILIC DESIGN PATTERNS & BIOLOGICAL RESPONSES

The table illustrates the functions of each of the 14 Patterns in supporting stress reduction, cognitive performance, emotion and mood enhancement and the human body. Patterns that are supported by more rigourous emphirical data are marked with up to three asterisks (***), indicating that the quantity and quality of available peer-reviewed evidence is robust and the potential for impact is great, and no asterisk indicates that there is minimal research to support the biological relationship between health and design, but the anecdotal information is compelling and adequate for hypothesizing its potential impact and importance as a unique pattern.

	14 PATTERNS	*	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	Visual Connection with Nature	***	**Lowered blood pressure and heart rate** (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	**Improved mental engagement/ attentiveness** (Biederman & Vessel, 2006)	**Positively impacted attitude and overall happiness** (Barton & Pretty, 2010)
	Non-Visual Connection with Nature	**	**Reduced systolic blood pressure and stress hormones** (Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991)	**Positively impacted on cognitive performance** (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundström, 2004)	**Perceived improvements in mental health and tranquility** (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003)
	Non-Rhythmic Sensory Stimuli	**	**Positively impacted on heart rate, systolic blood pressure and sympathetic nervous system activity** (Li, 2009; Park et al, 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)	**Observed and quantified behavioral measures of attention and exploration** (Windhager et al., 2011)	
	Thermal & Airflow Variability	**	**Positively impacted comfort, well-being and productivity** (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005)	**Positively impacted concentration** (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	**Improved perception of temporal and spatial pleasure (alliesthesia)** (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
	Presence of Water	**	**Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure** (Alvarsson, Wiens, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006)	**Improved concentration and memory restoration** (Alvarsson et al., 2010; Biederman & Vessel, 2006) **Enhanced perception and psychological responsiveness** (Alvarsson et al., 2010; Hunter et al., 2010)	**Observed preferences and positive emotional responses** (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphryes et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983)
	Dynamic & Diffuse Light	**	**Positively impacted circadian system functioning** (Figueiro, Brons, Plitnick et al., 2011; Beckett & Roden, 2009) **Increased visual comfort** (Elyezadi, 2012; Kim & Kim, 2007)		
	Connection with Natural Systems				**Enhanced positive health responses; Shifted perception of environment** (Kellert et al., 2008)
NATURAL ANALOGUES	Biomorphic Forms & Patterns	*			**Observed view preference** (Vessel, 2012; Joye, 2007)
	Material Connection with Nature			**Decreased diastolic blood pressure** (Tsunetsugu, Miyazaki & Sato, 2007) **Improved creative performance** (Lichtenfeld et al., 2012)	**Improved comfort** (Tsunetsugu, Miyazaki & Sato 2007)
	Complexity & Order	**	**Positively impacted perceptual and physiological stress responses** (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)		**Observed view preference** (Salingaros, 2012; Hägerhäll, Laike, Taylor et al., 2008; Hägerhäll, Purcella, & Taylor, 2004; Taylor, 2006)
NATURE OF THE SPACE	Prospect	***	**Reduced stress** (Grahn & Stigsdotter, 2010)	**Reduced boredom, irritation, fatigue** (Clearwater & Coss, 1991)	**Improved comfort and perceived safety** (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)
	Refuge	***		**Improved concentration, attention and perception of safety** (Grahn & Stigsdotter, 2010; Wang & Taylor, 2006; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)	
	Mystery	**			**Induced strong pleasure response** (Biederman, 2011; Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001)
	Risk/Peril	*			**Resulted in strong dopamine or pleasure responses** (Kohno et al., 2013; Wang & Tsien, 2011; Zald et al., 2008)

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Figure 1.1 Biophilic Design Patterns & Biological responses. This figure illustrates the outcomes of various biophilic design interventions. Reprinted from *14 Patterns of Biophilic Design* (p. 12), by W. Browning, C. Ryan, & J. Clancy, 2014, New York, NY. Terrapin Bright Green LLC. Copyright [2014] Terrapin Bright Green.

1.2 Background on Biophilic Design

Scales of Biophilic Design

Direct experience of nature, indirect experience of nature, and spatial/place-based experiences encompass the types biophilic design elements that can be used in the built world. It is also important to note that each of these elements or patterns can be found at three different scales in the built environment.

The first scale is the element level, the smallest of the scales. This refers to a single object or product that incorporates biophilic design. This may include a wooden desk, a potted plant, a biomorphic chair, or a pod that provides refuge. The element level is one of the easier scales to implement, as it involves bringing new elements into the space, rather than changing the space itself. Element scale biophilic design interventions can occur at any point in a design or redesign process and are likely cheaper than the other two scales as they are small and less effort intensive to implement.

The second scale is the floor level of a building. This refers to design elements that are integrated at a larger scale than an individual element, but do not apply to the whole building. For example, these designs will affect the walls, floors, ceilings, and spatial layout of the space. Continuing the example of plants, a floor level biophilic design intervention would be a green wall. This is much larger than a potted plant, but it exists on one floor of a building and does not influence the structure or the form of the building. These interventions will be more expensive than the element level, however, due to their size, they have the ability to reach and impact more people in the space. Additionally, the quality tends to be higher, as integration of a large-scale

intervention generally requires more thought and foresight into the design, creating higher quality biophilically designed spaces. Generally, floor level interventions can most easily be incorporated during an interior fit out or a renovation, as these elements are larger than element level objects and require changes to the floor of a building.

The last scale is the building level. This is the largest of the biophilic design scales and it influences the entirety of a building. This level of biophilic design is the most holistic type of biophilic design, because it is not just about the structure of the building, but also how it fits in to the surrounding landscape. Biophilic design at the building scale requires an in-depth study of site itself and understanding how sun, wind, topography, hydrology, and plant ecology influence the building. It also requires exploration of the site, determining which areas should be highlighted. By orienting the building towards natural views, creating organic shapes that mesh with the surrounding landscape, and using xenoscaping, buildings can incorporate biophilic design at a much larger scale. Continuing the example of integrating plants, a building scale example of this biophilic design intervention would be a green façade or a green roof. It would be an added bonus if these spaces grew herbs that could be harvested and used in the building's cafeteria. Other examples are buildings with biomorphic forms, inspired by the natural landscape and designed to fit seamlessly into it, rather than standing out. The easiest way to incorporate biophilic design at the building level is during new construction, as there are less constraints to what can be done with the site. While it is possible to do a series of renovations that adds to an existing building, new construction will allow for higher quality biophilic design at this level.

Resources and Standards

In the last few years, many resources have been developed that support the understanding and practice of biophilic design for both design professionals and clients. A majority of these resources are printed materials, including books, reports, white papers, case studies, and blogs on biophilic design. Some of the most well-known resources include books written by Stephen Kellert, a pioneer of biophilic design, as well as guides published by organizations dedicated to sustainability and biophilic design, such as Terrapin Bright Green and Interface. The content of these resources is very comprehensive, ranging from the philosophy behind biophilic design, the patterns, elements, and principles of it, guides on how to practice it, reports of successful case studies, research on biophilic design interventions, and value propositions for biophilic design.

In addition to printed materials, many companies hold educational events, such as design charrettes, lunch and learns, lectures, and conferences focused on biophilic design. These events bring biophilic design to design professionals and educate them in an engaging, more hands-on manner. Examples of these educational events include the International Living Future Institute's annual Living Future unConference, lunch and learn events hosted by the United States Green Building Council, and design charrettes run through Terrapin Bright Green and Oliver Heath Design (IFLI, 2018e; Oliver Heath Design, n.d.; Terrapin Bright Green LLC, 2018c; USGBC, 2018).

Lastly, online courses on biophilic design have been emerging, as well as a growing trend of including biophilic design in higher education through lectures or fully dedicated courses on biophilic design. The American Society of Interior Design

(ASID) teaches an online course on biophilic design for interior design professionals (American Society of Interior Designers, 2015). Additionally, other organizations like Greenbuild University, The Green Building Research Institute, and RedVector hold similar classes on biophilic design for professionals (GBRI, 2018; Greenbuild University, 2014; RedVector, 2018). In higher education universities, biophilic design is also being taught. Programs with courses dedicated to biophilic design include the University of Pennsylvania Design School's Ecological Architecture Certificate, Pratt Institute's Biophilic Design Seminar, the Rhode Island School of Design's Nature Lab, University of California Berkeley's Center for the Built Environment, and many more (Pratt Institute, n.d.; Rhode Island School of Design Nature Lab, 2018; Ryan, 2015; University of Pennsylvania School of Design, 2018).

Beyond these resources, some building standards have begun to incorporate biophilic designs into their certifications. The Living Building Challenge, one of the most stringent performance-based sustainability standards, has a biophilic design component, Imperative 9, under their health and happiness petal (International Living Future Institute [ILFI], 2016). All certified buildings must detail a biophilic design plan that utilizes elements that evoke a human nature connection. Projects attempting certification must have at least a one-day visioning session that occurs in the early phases of the design process (ILFI, 2016). The projects must consider some main areas of biophilic design including, light and space, natural shapes and forms, environmental features, natural patterns, place-based relationships, integration into the natural landscape, and opportunity for frequent interaction with nature (ILFI, 2016).

Another building standard that promotes biophilic design is the WELL building standard. The WELL building standard is a relatively new third-party building certification that has been gaining momentum due to its focus on health and well-being (International WELL Building Institute [IWBI], 2017c). Biophilic design is a requirement under their mind concept. Feature 88 is a precondition, meaning a requirement, to ensure a biophilic design narrative in every project. The narrative must discuss how nature is incorporated through light, environmental elements, spatial layout, and patterns (IWBI, 2017a). It must also address the opportunities for human nature interactions in the interior environment and on the surrounding site (IWBI, 2017a).

Beyond a narrative plan of incorporating biophilic design, the WELL building standard has a second feature focused on biophilic design, feature 100 (IWBI, 2017b). This feature is a quantitative report of biophilic design in a building and is an optimization, thus it is not mandatory for all projects. To meet this optimization, 25% of the project site must have landscaped grounds or roofs that are accessible to occupants and have at least 70% of the ground covered in plantings and tree canopies (IWBI, 2017b). Additionally, potted plants or plant beds must cover at least 1% of floor area per floor and one plant wall must be included per floor that covers at least 2% of the floor areas or covers the largest wall area (IWBI, 2017b). Lastly, there must be at least one water feature every 9,290 m^2 that is 1.8 m in height or 4 m^2 in area (IWBI, 2017b). There must also be ultraviolet sanitation for the water features to ensure water safety. These requirements are included in a letter of assurance, written by the project architect and then verified during a site visit (IWBI, 2017b).

While it is a step in the right direction to require biophilic design in the built environment, there has been some backlash against the quantitative biophilic design requirement in the WELL building standard. Since biophilic design is a design philosophy, dictating certain amounts of a specific element seems limiting when it comes to design. While the incorporation of plants in a space has positive impacts, it is hard to determine why the standard settled on these percentages, which may deter some designers from using it. Certain spaces may be unable to dedicate 1% of their floor plan to plants because the indoor environment may not be conducive to growing plants in its interior spaces due to quality of light. Additionally, there are other ways to include biophilia, whether indirectly or spatially, that may suit the space more than these specific ratios of plants and water to space.

Current State of Biophilic Design

Organizations like the International Living Future Institute (ILFI), the International WELL Building Institute (IWBI), Biomimicry 3.8, Interface, and Terrapin Bright Green have been expanding knowledge in the field and promoting biophilic design in practice (ILFI, 2018c; IWBI, 2017a, 2017b; Biomimicry 3.8, 2016; Interface, 2018; Terrapin Bright Green LLC, 2018). While there is a plethora of research and resources about biophilic design, the current state of the building design industry has been slow to uptake this design ethos. According to the Biophilic Map, there are 41 recognized buildings that incorporate biophilic design (ILFI, n.d.). Add the 15 projects that have achieved Living Building Challenge Certification, 61 that have achieved WELL gold and platinum certification, 1 building that received the

Stephen Kellert Biophilic Design Award, and 15 or so case studies that exist online, it seems as if there are only 133 recognized cases of biophilic design in commercial architecture (ILFI, 2018a, 2018c, 2018d; IWBI, 2017d; Terrapin Bright Green LLC, 2018b). This number seems incredibly low, which is possible because many buildings have incorporated biophilic elements before these standards existed or are yet to be recognized. Still, it is clear that biophilic design exists in only a small sliver of buildings around the world.

The state of current office buildings can be described as shocking. It has been reported that 47% of global workplaces have no natural light in their offices (Human Spaces, 2015). Additionally, 19% of offices are lacking any form of natural elements (Human Spaces, 2015). Consequently, only 39% of workers reported feeling optimally productive in the last three months (Human Spaces, 2015). That means that the majority of employees do not feel productive in their current workplaces. When asked what elements employees desired in a workplace, the response showed that some of the most desired elements, like natural light, indoor plants, a quiet workspace, views of the sea, and bright colors, are biophilic design elements (Human Spaces, 2015).

A desire for biophilic design in clear in workplaces. While the number of case studies of successful biophilic design is growing, poor implementation of biophilic design does occur, which prevents users from reaping the benefits of interacting with nature. Examples of poor implementation that the field can learn from encompass four notions: poor integration with the space, no sustained connection to nature, poor placement, and a lack of diverse biophilic elements (Kellert, 2015).

Biophilic design is a well thought out design philosophy that requires an understanding of the space and an integration of design elements to elicit positive responses (Kellert et al, 2008). When singular elements are disparately placed around a space, the design lacks cohesion, which is essential to good biophilic design (Kellert, 2015). For example, an office with a singular water feature, but no other elements that attempt a connection to nature, lacks authenticity and will not be effective.

Biophilic design also requires a sustained connection to nature, so projects that do not design for a prolonged connection to these natural elements are not effective (Kellert, 2015; Kellert & Calabrese, 2015). For example, placing biophilic design elements in transitional spaces does not allow occupants to engage with them for the sustained amount of time that is necessary to reap the benefits of it. This is related to the third category, poor placement of biophilic design elements. Beyond a sustained experience of these elements, they must be placed in areas that are accessible to occupants (Kellert, 2015). This can be placed proximally, so one can see, touch, or smell, or at a distance that can be seen through peripheral vision. A common example of a poorly implemented biophilic design is a lounge area with a green wall that has seating placed in front of it. Instead of the chairs facing the green wall, allowing users to have visual access to it, the chairs face away from it, allowing for little interaction with the design element.

The final type of poor biophilic design is a lack of diverse biophilic design elements (Kellert, 2015). When most people think of biophilic design, all that they envision is placing plants inside of buildings. While that is one way to achieve biophilia in space, it is not the epitome of biophilic design. Instead of filling a space

with plants, designers should focus on the outcomes desired in the space. While plants may improve satisfaction with the space, it may not be the best element to reduce stress or promote productivity. Instead, other biophilic design elements, such as an indirect connection to nature, may be better suited for the space.

1.3 Examining the Gap between Research and Application

In the literature, it is clear there exists relevant research and theories on biophilia and biophilic design. However, the practice of biophilic design has yet to be adopted as an industry norm. Architects and designers still seem to be missing the mark on what biophilic design is, incorporating disparate evocations of nature that cannot foster a sustained connection. Additionally, the state of the current workspace needs to change in order to promote healthy, inspired, happy, productive occupants. This can be achieved by changing the state of commercial design and demanding spaces that provide occupants with a connection to the outside world that is dictated by our evolution.

The objective of this thesis is to examine this gap and answer the question, how can the practice of biophilic design be improved and diversified to promote human health and environmental quality? There has yet to be a study that identifies the barriers to practicing biophilic design, and thus this thesis will uncover the steps to move biophilic design towards the mainstream. To answer this overarching research question, this study must understand the current practice of biophilic design, the barriers towards implementing biophilic design, and how to improve and diversify the kind of biophilic design that is normally used. By recognizing these barriers, solutions

can be found to move the field forward, promoting biophilic design in architecture and design. Additionally, this exploratory research will generate new hypotheses surrounding biophilic design and create more research opportunities on the area. To obtain a clear understanding of the practice of biophilic design, a series of qualitative interviews were conducted with professionals in the field of architecture and design, who provided expert opinions for this project.

2. Methodology

Instrument Development

To investigate the research question of how to improve and diversify the practice of biophilic design, a qualitative interview was developed that would reveal the current state of biophilic design in practice and generate ideas of how to move the field forward. The interview was designed to be semi-structured with open-ended, exploratory questions that would allow participants to elaborate on their own experiences and opinions relating to biophilic design. The questions examined the core barriers to implementing a range of biophilic design patterns in practice, the current state of biophilic design, how biophilic design is normally implemented, and how to improve it in the future.

To understand the current state of biophilic design in a robust manner, professionals who practice architecture and design, as well as those who create design standards, were the target audience of the interview. Due to this dual audience, two sets of interview protocols were developed to target different stakeholders in the practice of biophilic design. One interview protocol was focused on practicing

architects and designers. This interview contained questions that fell into three focus categories about the biophilic design process, which can be seen in Figure 2.1. The first surrounded the existing knowledge that design professionals have about biophilic design and how is it used in practice. The second point had to address the barriers to implementing biophilic design in practice. Lastly, the interview had to ask questions about how to move the field forward and, more specifically, what tools designers need to do so.

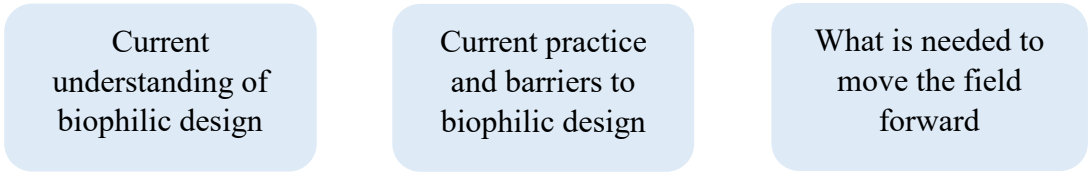

Figure 2.1 Design Professional Interview Focus. The three focus areas of the interviews for design professionals.

The other interview protocol was focused on design researchers who develop standards and guidelines for biophilic design. The focus of this interview also fell into three distinct categories, which can be seen in Figure 2.2. This interview had to highlight how standards for biophilic design are developed and the process behind creating standards. It also had to determine which biophilic design strategies are incentivized within these standards. Lastly, the interview had to examine how customers use these certification systems, as it would explore if biophilic design standards influence how biophilic design is practiced.

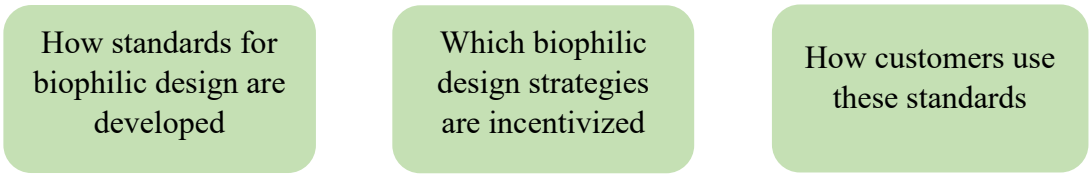

Figure 2.2 Design Researcher Interview Focus. The three focus areas of the interviews for design researchers.

From this starting point, research was conducted on existing interview protocols that investigated barriers to implementing new types of design. Additionally, guidelines for creating open-ended, exploratory questions were searched. Following the guidelines of Turner (2010), the questions that were developed were open-ended, clearly worded, and neutral in nature. Lastly, key points from the literature about biophilia and biophilic design were re-examined.

After consulting the literature, a series of questions were developed that addressed the six objectives of the interview, mentioned above. The Theoretical Domains Framework, which is a framework that addresses 14 domains that may influence implementation (Weatherson, McKay, Gainforth, & Jung, 2017), was consulted during interview development. Seven of the 14 domains were chosen because they tie in closely to the architectural and design practice. These domains are: knowledge, skill, social role and identity, goals, environmental context and resources, intentions, and social influences (Atkins et al., 2017). Since design professionals must attend to their clients' needs, they do not have control over the whole design process, and thus, all 14 domains do not apply to them. The seven domains that were chosen address what they can control regarding implementation of biophilic design and thus, guided some interview question development. The interview questions that correspond with each of these categories is listed in Table 2.1.

Table 2.1 *Theoretical Domains Framework and Instrument Development*

Theoretical Domains Framework Category	Question
Knowledge	Have you heard of biophilia or biophilic design? Can you define biophilic design in your own terms?
Skill	Do you use biophilic design in practice? Can you give me an example of a project that used biophilic design?
Social Role and Identity	Please tell me a bit about the company you work for. What is your position at the company?
Goals	Can you think of ways to attract clients to use combinations of biophilic design patterns?
Environmental Context and Resources	Do you know of any research or resources on this topic that you suggest to clients or look at yourself? What type of resources would you want? What would you like to see more of?
Intentions	Do you see yourself as an advocate for biophilic design?
Social Influences	What would be the best way to promote biophilic design to other professionals? And clients?

Validated measures regarding barriers to implementing new types of design are limited in the architecture and design fields. Due to this, some interview questions were based off interviews in the healthcare industry, as there are many documented interviews regarding the barriers to implementing new tools and services. The remainder of the questions were developed to answer key points about the current state of biophilic design, barriers to specific biophilic design categories that were discussed in the literature review, tools desired by professionals, and how standards are developed and used. A final list of the questions can be found in Appendix A.

Interview Structure

All participants were asked seven introductory questions aimed at recording where they work and what they do, as well as their current understanding of biophilic design. From there, two sets of interview questions were developed that focused on two different perspectives. The first was of professional architects and designers, the people who use biophilic design and practice. These questions pertained to how biophilic design is used in practice, the barriers to implementing it, and how to encourage biophilic design among professionals and clients, which can be found in Table 2.2. The second was of design researchers who create guidelines and standards of biophilic design. As seen in Table 2.3, these questions were focused on understanding how standards are developed, which strategies of biophilic design are incentivized, how their customers use these standards, as well as identifying the largest barriers to implementing biophilic design.

Table 2.2 *Interview Question Themes Answered by Design Professionals*

Category of Question	Question Number
How biophilic design is used in practice	8-10, 13-14, 16-17, 19-20, 22-23, 25
Barriers to implementing biophilic design	15, 18, 21, 27
How to encourage biophilic design	11-12, 24, 26, 28-30

Table 2.3 *Interview Question Themes Answered by Design Researchers*

Category of Question	Question Number
How standards are developed	8-12
Which strategies of biophilic design are incentivized	13, 21-27
How customers use standards	14-20
Identifying the largest barriers to implementing biophilic design	28

The interview was then reviewed by a research professional, who clarified the wording of certain questions. For example, in the section of questions that discuss the different categories of biophilic design, the definitions of direct experience of nature and spatial experiences were clarified. It was also suggested that questions 14, 17, and 20 should operationalize project use in quantitative measures, so the wording was altered to allow participants to answer with percentages of their total projects.

After this initial review, two pilot interviews were conducted with people who have previously worked in the design field. The interviews generally lasted around 25-40 minutes. These pilot interviews highlighted some issues in the order of the interview and which questions needed more clarity. For example, in one of the pilot studies it was noted that question seven should clarify that it is asking about the best practice of biophilic design in the built environment, as biophilic design can also occur in other fields like landscape design and city planning. These problems were corrected

and resulted in the final interview, which can be found in Appendix A. The final interview protocol flow can be seen in Figure 2.3, below.

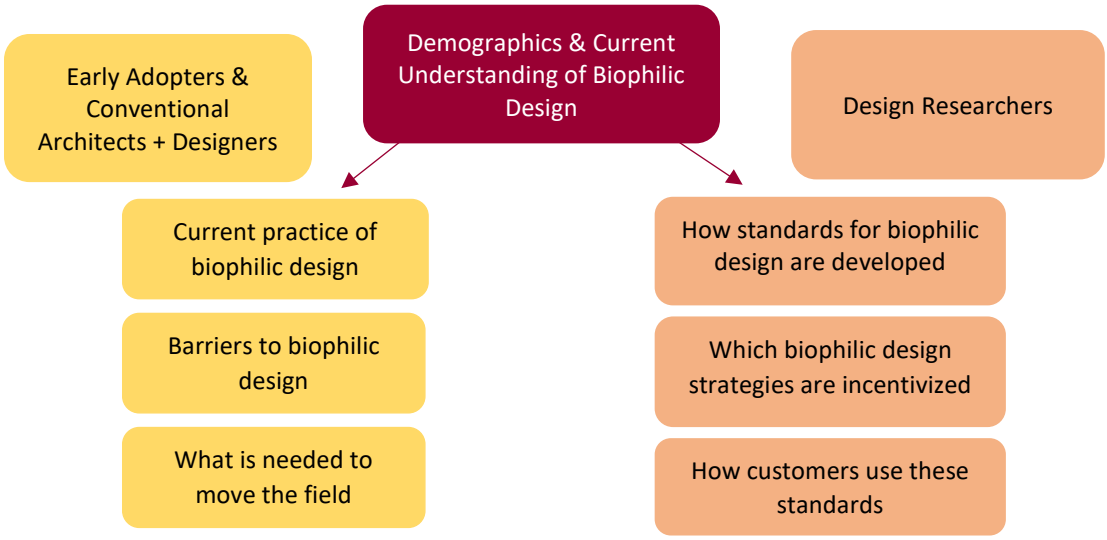

Figure 2.3 Final Interview Protocol Flow. The flow of the interview for the participant groups.

Sample

The interviews were conducted with professionals in the field of architecture and design, who served as industry experts. Expert participants were chosen because they have a vast knowledge of the architecture and design field and thus, can examine the factors preventing biophilic design from becoming a typical practice. Three types of professionals were recruited for this research, as seen in Figure 2.4.

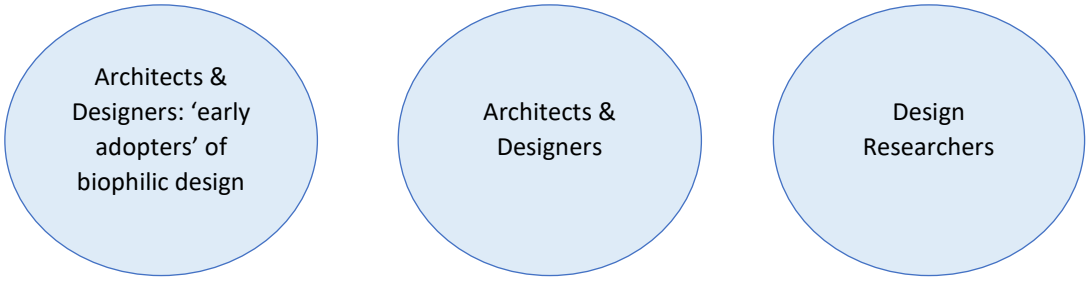

Figure 2.4. Groups of Interview Participants. Participants fell into three groups of professionals.

The first group consisted of architects and designers who were designated 'early adopters' of biophilic design, which, for the purposes of this thesis, was defined as professionals or organizations who published papers or reports about biophilic design. Those who had their own biophilic design practice also fell into this group. The second group of professionals were conventional architects and designers, who were currently employed and were not involved in a practice dedicated to biophilic design. The last group of participants were design researchers, who create standards and guidelines for biophilic design in practice. These three groups of professionals fell onto a spectrum related to biophilic design, as some extensively research the theory behind it, some implement it in practice extensively, and some are new to the concept. The range of understanding about biophilic design within these distinct groups of professionals provided a more complete idea of how biophilic design is implemented at three different professional scales.

It was decided that three to four representatives from each group, thus creating a total of nine to twelve respondents, would be the desired sample for this study. To recruit for this study, an extensive search was conducted, which complied architectural and design firms that practice commercial architecture. To define the group of 'early adopters', design firms and individuals that had previously published papers on biophilic design were searched. Another search was conducted on individuals who run their own biophilic design practice. The results of this generated a group of expert designers who were early adopters of biophilic design. Those who fell into this group were recruited through email, with a letter than can be found in Appendix B.

To recruit the category of conventional architects and designers, a convenience sample was conducted. Alumni from the Cornell University Architecture program and the Cornell University Design and Environmental Analysis program were contacted via email, which can be found in Appendix B. The hope was to get a sample of young professionals who worked in medium and large commercial architecture firms.

To recruit for the design researcher category, three organizations were targeted. The first two, the International Living Future Institute and the International WELL Building Institute, created building standards that require biophilic design. These organizations were recruited to get a better understanding of the standard development process. The last firm, Terrapin Bright Green, was recruited because it has published extensive guidelines on how to practice biophilic design, case studies, and the business case for biophilic design. Emails were sent to the general inquiries section of these organization's websites. Additionally, biophilic design managers at the firms were contacted via LinkedIn. The recruiting letter can be found in Appendix C.

The final sample size of the study was ten, with four respondents in the 'early adopter' of biophilic design category, three in the 'conventional' architect and design category, and three in the design researcher category. The respondents represented a broad spectrum of biophilic design knowledge and experience, which provided a clear picture to what the current state of biophilic design is.

Analysis

After conducting the interviews, the responses were transcribed, aided by Sonix.ai, to allow for content analysis, a process of coding and categorizing the data (Vaismoradi, Turunen, & Bondas, 2013; Hsieh & Shannon, 2005). Responses were then organized and coded via emergent codes. Thematic analysis was also conducted to determine the patterns across the responses, to understand the current state of biophilic design in the architecture world, the barriers to it, and how to move the field forward.

3. Data Analysis

The interview responses illuminated a series of insights into the practice of biophilic design. The following analysis section will discuss the several themes that emerged from the analysis process in these three categories: the current state and use of biophilic design, the barriers to implementing biophilic design strategies, and ways to promote biophilic design in the future. Each of the categories will be discussed from the perspective of the three groups of participants, early adopters of biophilic design (early adopters), conventional architects and designers (conventional architects), and design researchers who set standards of biophilic design (design researchers).

Participant Sample

Table 3.1 details the breakdown of each of the three groups of participants, including what company each participant works for, the size and location of the company, and the position that they hold at each company. The early adopters all held

high positions in firms dedicated to biophilic design, sustainability, or health and wellness. The design researchers worked at companies that have produced standards or guidelines for biophilic design. The conventional architects and designers were young professionals at firms with no specific focus on biophilic design.

Table 3.1 *Summary of Participants in the Interview*

Group	Participant	Company	Company Size	Location	Position
Early Adopters	Early Adopter A	Gensler	Large	New York	Sustainability Director
	Early Adopter B	Delos Ventures	Large	New York	Senior Director
	Early Adopter C	Oliver Heath Design	Small	Brighton, England	Founder and Director
	Early Adopter D	Calabrese Architects	Small	Burlington, VT	Principal Architect
Conventional Architects and Designers	Architect A	Chiang O'Brien Architects	Mid-size	Ithaca, NY	Designer
	Designer B	LB Architects	Mid-size	New York	Job Captain
	Architect C	Payette Architects	Large	Boston	Architectural Designer
Design Researchers	Design Researcher A	Terrapin Bright Green	Mid-size	New York	Founding Partner
	Design Researcher B	International Living Future Institute	Large	Seattle	Biophilic Design Manager
	Design Researcher C	International WELL Building Institute	Large	New York	Chief Commercial Officer

3.1 The Current State of Biophilic Design

Knowledge and Understanding of Biophilic Design

All of the 10 respondents were familiar with the term biophilic design before this interview. Two groups of participants, early adopters and design researchers, had learned about the concept early, defined as between the years of 2000 and 2010, except for one design researcher. The group of conventional architects had learned about biophilic design, later, between the years 2014 and 2015, as seen in Table 3.2.

When asked to define biophilic design in their own terms, all respondents mentioned bringing in nature or natural elements into a space, which can be seen in Table 3.2. Nine out of ten interview respondents included humans in their definition, whether it be about evoking an emotion in humans (20% of participants) or touching upon a connection to nature (40% of participants). 70% of the participants mentioned an innate, evolutionarily based affinity or attraction towards nature in their definitions. 20% of participants included an integration or connection to natural processes in their definition. It is clear that the early adopters and design researchers had more extensive definitions than the conventional architects, as their responses included more codes about various elements of biophilic design.

Table 3.2 *Breakdown of Participants Prior Knowledge of Biophilic Design*

Group	Participant	Year learned about biophilic design	Definition of biophilic design coded
Early Adopters	Early Adopter A	2008	evolution-based affiliation; incorporating nature/natural elements; human
	Early Adopter B	n/a	evolution-based affiliation; incorporating nature/natural elements; connection to nature; human
	Early Adopter C	2010	evolution-based affiliation; human; incorporating nature/natural elements; natural systems and processes; evoking emotion
	Early Adopter D	2008	human; incorporation of nature/natural elements; natural systems and processes; evolution-based affiliation
Conventional Architects & Designers	Architect A	2014	incorporating nature/natural elements; human; evoking emotion
	Designer B	2014	incorporating nature/natural elements; connection to nature
	Architect C	2014	incorporating nature/natural elements; human
Design Researchers	Design Researcher A	2000s	incorporating nature/natural elements; human; connection to nature; evolution-based affiliation
	Design Researcher B	2014	incorporation of nature/natural elements; human; evolution-based affiliation
	Design Researcher C	2008	Incorporation of nature/natural elements; human; evolution-based affiliation; multisensory; connection to nature

Value of Biophilic Design

When asked if biophilic design held value for the field of design, all ten the of respondents stated that biophilic design is valuable. Three themes emerged as to why biophilic design is valuable, as seen in Figure 3.1. These themes are health and well-being, productivity, and reconnection to nature.

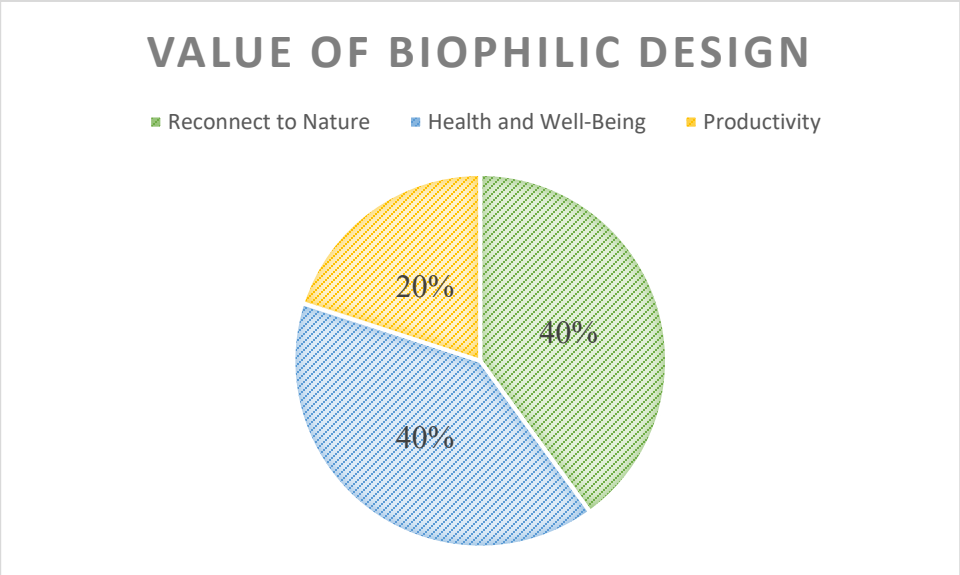

Figure 3.1. Value of Biophilic Design. Reasons why the participants felt biophilic design holds value.

Health and well-being. Four of the ten respondents, and three of the four early adopters, felt that the value in biophilic design is related to how it improves human health and well-being. The respondents noted health and wellness, stress reduction, and healthy habitats as ways that biophilic design holds value. For example, one states,

> stress is endemic in our modern lives…that stress leads to illness…design has a role to play…we need to start to interweave those ideas [positive experiences in nature] to create micro-recuperative spaces so that health and well-being is

> much more than a trip to the gym or the doctor, it should be drip fed into us all the time. (Early Adopter C, Oliver Heath Design, 2018).

Another notes, "…we're going to learn a lot more about the detrimental impact that [interior environment] has on our body and start to find ways that we can mimic exterior environments so that we realign ourselves to our evolutionary past" (Early Adopter B, Delos Ventures, 2018).

Productivity. Two of the ten respondents felt that the value of biophilic design stems from how it can improve productivity. These participants fell into the conventional architects and the design researchers group. One notes, "…I noticed when I was on campus in college, I would always study in a space that had better lighting, or had better natural materials, like wood…and that had an impact on how I studied, my efficiency, and my productivity" (Architect C, Payette Architects, 2018). Terms used to describe productivity included efficiency, productivity, and bottom line.

Reconnecting to Nature. Four of the ten respondents felt that the value of biophilic design stems from the problems caused by isolation from nature in the modern world. They feel that reconnecting to nature will solve some detrimental impacts that come from disconnection from nature. Two of the three conventional architects and designers fell into this category, as well as one early adopter and one design researcher. One notes that designers "…are ultimately solving problems, and a lot of the problems we face are because we've divorced ourselves from nature" (Design Researcher B, International Living Future Institute [ILFI], 2018). Some of

these problems include lack of access to daylight, lack of fresh air, and artificial lighting, which can lead to physical and mental illness.

Personal Value. While not a theme that the participants directly mentioned, it is also important to note that in addition to these themes, one of personal value also emerged, as one-third of the respondents who described the value of biophilic design put it in terms of their own experience. This was seen in the discussion of productivity and can be noted when one respondent says,

> especially being in New York, it's really hard to incorporate nature, even into our lives, on a daily basis. So then, when you're stuck in a building and then on a train and then going into a building and into another building, you get zero nature because, even on your walk you're not exposed to anything…I'm more aware of it now that I've been living here. (Designer B, LB Architects, 2018).

This notion of value stemming from personal experience with nature is seen again, when trying to create a value proposition for biophilic design, so it is important to bring up that it is how people are thinking about biophilic design. It is not only about the outcomes that can be quantified, but also those that can connect people to their own experiences of the value of nature.

Best Practice of Biophilic Design

All of the participants were asked to identify a building or a space that exemplifies the best practice of biophilic design, to understand what aspects of

biophilic design are truly valued practice. The buildings are detailed below with a discussion of themes of perceived best practices.

1. **Delos Headquarters, New York, NY.** This space is aiming to get a trifecta of sustainability certifications: LEED platinum certification, Living Building Challenge certified, and WELL platinum certification. As shown in Figure 3.2, the space incorporates visual access to nature, a material connection to nature, green walls that double as air purification units, and physical access to a green roof. “We have about 21 Naava green walls in the space right now and the design intent, from that aspect is to, no matter where you are standing within the space, have your line of sight go to a Naava green wall.” “We are also situated right on the high line here in New

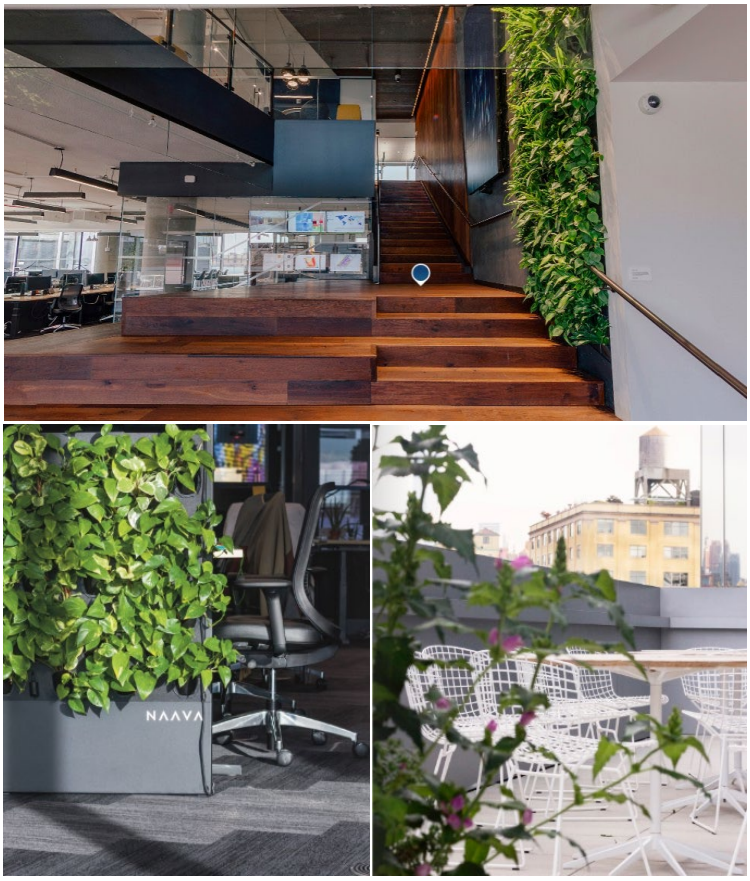

Figure 3.2. Collage of Delos Headquarters, New York, NY. Top: [Delos HQ Interior]. From “Explore Delos Headquarters in 360”, by Delos, n.d., https://delos.com/delosvr. Copyright [2018] by Delos Living, LLC. Bottom Left: [Delos HQ Green Wall]. From “Delos Headquarters 860 Washington Street” (p. 18), by Delos, n.d., https://delos.com/brochure/hq/DelosHQ.html#p=18. Bottom Right: [Delos HQ Terrace]. From “Delos Headquarters 860 Washington Street” (p. 8), by Delos, n.d., https://delos.com/brochure/hq/DelosHQ.html#p=8.

York, so there is a great interplay between the exterior enviornment and the interior environment…" (Early Adopter B, Delos Ventures, 2018).

2. **Etsy Headquarters, Brooklyn, NY.** "I think there are a lot of good vignettes of biophilic design…We completed a project for the Etsy Headquarters and we put a lot of good stuff in there, we covered a lot of different elements of biophilic design, so I think that was an effective use" (Early Adopter A from Gensler, NY, 2018). As seen in Figure 3.3, the office space incorporates different patterns of biophilic design at various scales, such as visual access to nature through views and indoor plants, biomorphic shapes in the egg chair, dynamic lighting, and a material connection to nature in the wooden elements.

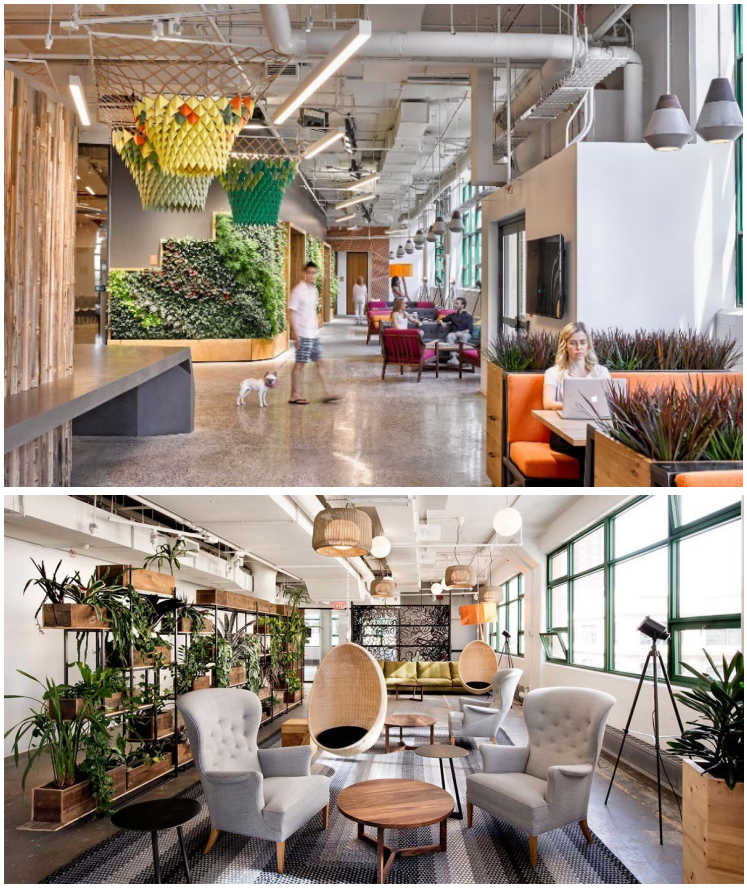

Figure 3.3. Collage of Etsy Headquarters, Brooklyn, NY. Top: [Etsy Headquarters], by G. Rowland, n.d., https://gbdmagazine.com/2017/typology-gensler/. Bottom: [Etsy Lounge]. From "Designing Our Living, Breathing Headquarters", by Etsy, Inc., n.d., https://www.etsy.com/fr/living-building-challenge.

3. **PARKROYAL on Pickering, Singapore; Khoo Teck Puat Hospital, Singapore; Amazon Headquarters, Seattle, WA.** The three buildings in Figure

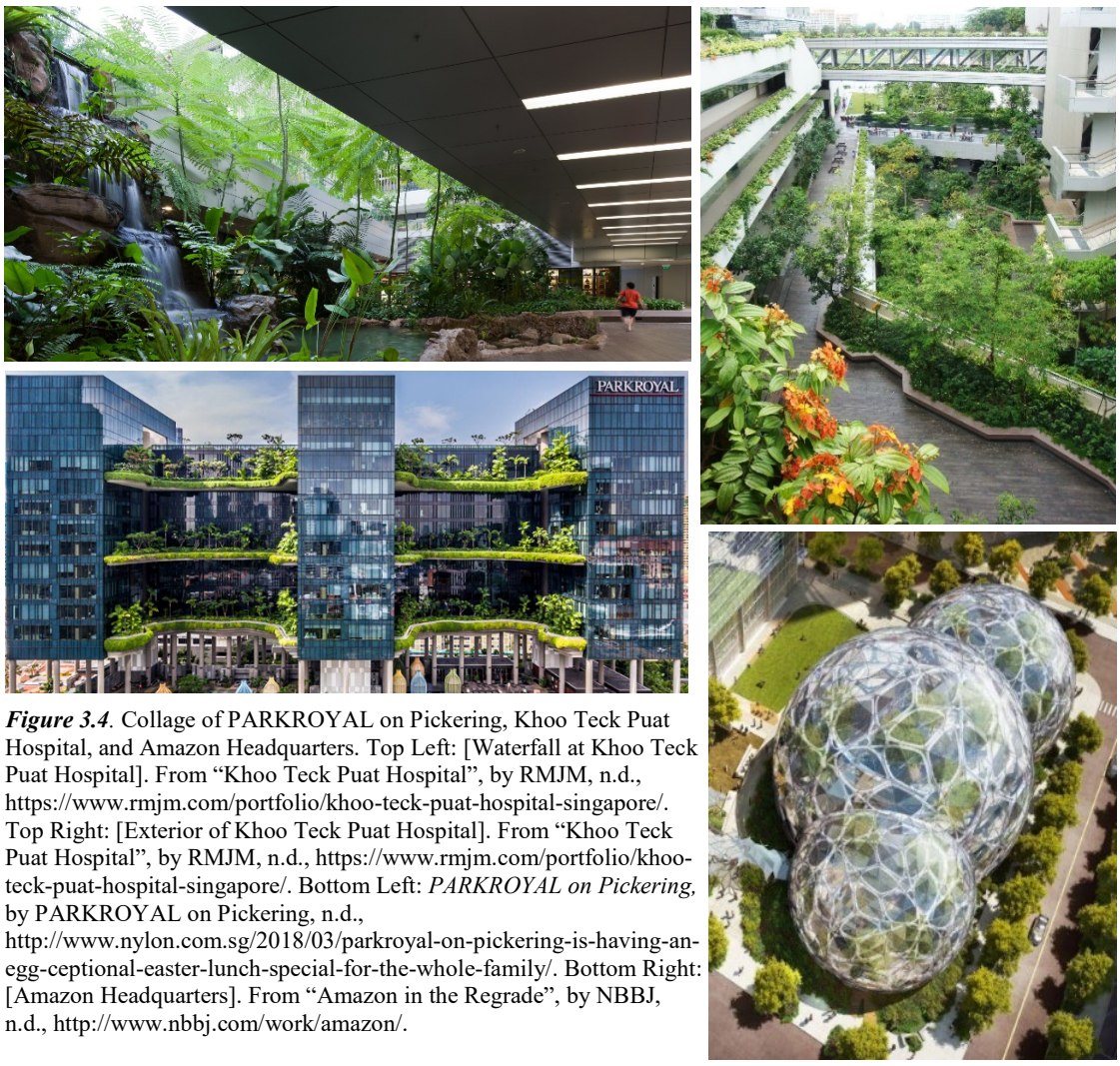

Figure 3.4. Collage of PARKROYAL on Pickering, Khoo Teck Puat Hospital, and Amazon Headquarters. Top Left: [Waterfall at Khoo Teck Puat Hospital]. From "Khoo Teck Puat Hospital", by RMJM, n.d., https://www.rmjm.com/portfolio/khoo-teck-puat-hospital-singapore/. Top Right: [Exterior of Khoo Teck Puat Hospital]. From "Khoo Teck Puat Hospital", by RMJM, n.d., https://www.rmjm.com/portfolio/khoo-teck-puat-hospital-singapore/. Bottom Left: *PARKROYAL on Pickering,* by PARKROYAL on Pickering, n.d., http://www.nylon.com.sg/2018/03/parkroyal-on-pickering-is-having-an-egg-ceptional-easter-lunch-special-for-the-whole-family/. Bottom Right: [Amazon Headquarters]. From "Amazon in the Regrade", by NBBJ, n.d., http://www.nbbj.com/work/amazon/.

3.4 incorporate biophilic design in a different manner. The Khoo Teck Puat Hospital received the Stephen Kellert Biophilic Design Award in 2017 for its incredible incorporation of biophilic design and ability to promote well-being. PARKROYAL on Pickering blends green terraces with a modern hotel. Beyond the greenery, guests have access to water, chairs that are organically shaped, and prospect views. Lastly, Amazon's Headquarters in Seattle uses biomorphic domes, prospect-refuge, and indoor plants to evoke a connection to nature.

4. **The Omega Center for Sustainable Living, Orange County, NY.** Two

Figure 3.5. Collage of the Omega Center for Sustainable Living, Orange County, NY. Top: [Exterior of Omega Center]. From "Omega Center for Sustainable Living", by BNIM, n.d., https://www.bnim.com/project/omega-center-sustainable-living. Bottom Left: [Omega Center Living Machine]. From "Omega Center for Sustainable Living", by BNIM, n.d., https://www.bnim.com/project/omega-center-sustainable-living. Bottom Right: [Omega Center Yoga Studio]. From "Omega Center for Sustainable Living", by Assassi Productions, n.d., https://www.bnim.com/project/omega-center-sustainable-living.

participants chose this building as a best practice of biophilic design. One notes, "It is a building, but it also seems like a creature. It filters its own water and then reuses the waste water, harvests solar energy, and also inside, there are these plants as decoration and at the same time, they use them as a way to purify the water" (Architect A, Chiang O'Brien Architects, 2018). The notion of natural processes is central to this quote. This building is one of the first Living Building Challenge certified buildings and features a living machine. The space creates access to natural views, incoporation of plants, integration of natural proccesses and

systems, creates a material connection to wood and stone, and provides prospect in its spaces, which can be seen in Figure 3.5.

5. **Evolable Asia Office, Vietnam.** As seen in Figure 3.6, this space incorporates an artificial park, with indoor plants, biomorphic terrain, prospect and refuge, views of nature, and natural materials. One respondent states, "It was an open office space and, in the middle, they created a mini park atmosphere.

Figure 3.6. Evolable Asia Office, Vietnam. [Evolable Asia Interior]. From "Office Design in Ho Chi Minh City", by H. Oki, n.d., https://www.archdaily.com/889042/office-design-in-ho-chi-minh-city-07beach-plus-studio-happ.

They created a terrain, little hills, and they put Astroturf on it so that people during their lunch can sit there. So, it's a mimicked park and its so tiny, but walking around the office I presume that you get the same feeling as if you were outside…" (Designer B, LB Architects, 2018).

6. **COOKFOX Architects Office, New York, NY.** Two participants also mentioned the New York office of COOKFOX Architects. This space, as seen in Figure 3.7, has a green roof, a material connection to nature, incorporation of organic forms, visual acces to nature, prospect-refuge, and mystery. "Going off the more traditional definition of plants and daylight, there is a firm in New York City

Figure 3.7. Collage of COOKFOX Architects Office, New York, NY. Left: *COOKFOX Offices by COOKFOX (NY, NY); featured in Metropolis magazine.* By B. Dimitrova, n.d., http://www.bdphotography.com/cook-fox-offices#3. Right: [Office Interior]. From "250 West 57th Street", COOKFOX Architects, n.d., http://cookfox.com/project.php?id=250-West-57th-Street.

called COOKFOX Architects and they're really good about integrating plants into their office building and their customer's buildings, whether that be on balconies, exterior courtyards, or lots of daylight…I guess best practice would be incorporating plants, but then also more of the subtle nuances in material choices…curves could have a huge impact on human health and human behavior in space…" (Architect C, Payette Architects, 2018).

7. **Clif Industrial Bakery, Twin Falls, ID.** This industrial kitchen has biophilic

Figure 3.8. Collage of Clif Industrial Bakery, Twin Falls, ID. Left: [Clif Bakery Exterior]. By Clif Bar, n.d., https://inhabitat.com/clif-bars-new-idaho-bakery-is-an-eco-friendly-masterpiece-of-biophilic-design/. Right: [Clif Bakery Interior]. From "Clif Bar Manufacturing Bakery", by Babcock Design, n.d., http://www.babcockdesign.com/clif-bar.html.

design elements that enhance the sterile environment, as seen in Figure 3.8. "Within the bakery, we were able to get windows in, which doesn't seem like a huge thing, but if you look at most food processing facilities, you are not going to

see windows. The windows were helpful for the people on the daytime and swing shift, but don't do a whole lot for the folks at night. So the other thing we investigated was the idea of putting projectors or large screens that have pictures of nature on them" (Design Researcher A, Terrapin Bright Green, 2018). Use of technology can enhance interior spaces by drawing upon nature analogues.

8. **Te Kura Whare, New Zealand; Fallingwater, Mill Run, PA.** One participant brought up two examples of biophilic design that exemplify the importance of connection to place in design, which can be seen in Figures 3.9 and 3.10. Both Te Kura Whare and Fallingwater create intense connections to place, as one empowered a community to build it on land that had been stripped away from them over one hundred years ago and the other perfectly integrates into the landscape surrounding it. On Te Kura Whare, "…what was amazing to me was that they got a grant and so they [Tu Hoi Maori] were people who had basicallly been divorced from their land for hundreds of years, and they were able

Figure 3.9. Collage of Te Kura Whare. Top: [Te Kura Whare Exterior]. By D. Olsen, n.d., https://owtnz.com/project/te-kura-whare/. Bottom: [Te Kura Whare Interior]. By D. Olsen, n.d., http://architecturenow.co.nz/articles/te-uru-taumatua-te-wharehou-o-tuhoe/#img=3.

Figure 3.10. Fallingwater Connection to Place. [Fallingwater]. From "Fallingwater", by Frank Lloyd Wright Foundation, n.d., https://franklloydwright.org/site/fallingwater/.

to get that back, and got reparations, so they had money to invest and they decided they wanted to invest in their cultural heritage. Part of that was creating this community center that would preserve that, but in the process of doing it, they would also give everybody in the community valuable skills in regenerative building design…" (Design Researcher B, ILFI, 2018). Both of these buildings create a clear connection to land and the surrounding communities.

9. **Phipps Center for Sustainable Landscapes, Pittsburg, PA.** One participant mentioned this building, as seen in Figure 3.11, as an exemplar for providing a multisensory biophilic design experience. "They did everything from biophilic artwork to installing speakers that bring in sounds from the outside, like birds chirping…and they put that into their atrium space so that if you're walking up and down the stairs you get to hear that sensory experience" (International WELL Building Institute [IWBI], Design Researcher C, 2018). In

Figure 3.11. Phipps Center for Sustainable Landscapes, Pittsburg, PA. [Phipps Center for Sustainable Landscapes]. From "Center for Sustainable Landscapes", by Phipps Conservancy and Botanical Gardens, n.d., http://www.aiatopten.org/node/507.

addition to nature inspired artwork which proves access to natural sights and sounds, the building also incorporated a material connection to nature and a strong connection to place.

Diversity of Types of Biophilic Design. All ten respondents mentioned buildings that use a diversity of biophilic design elements in space. Even further, each uses all of the three categories of biophilic design, a direct connection to nature, an indirect connection to nature, and spatial/place-based experiences. A direct connection to nature is seen in access to windows with views, indoor plants or plant walls, natural sounds and thermal variability. An indirect connection is utilized through incorporation of natural materials, organic shapes and forms, and natural colors and textures. A spatial/place-based connection is achieved through prospect-refuge, mystery, and in some cases, a connection to place.

Connection to Place. Four of the participants chose buildings or spaces with an emphasis on connection place. This was seen in Te Kura Whare, Fallingwater, Phipps Center for Sustainable Landscapes, and the Omega Institute. All of these spaces connect with their surroundings, whether it is through visually fitting into the landscape, engaging with the community, or filtering wastewater and returning it the land.

Scale of Biophilic Design. Beyond incorporating various biophilic design elements in space, all of the buildings also incorporate various scales of biophilic

design. All of these spaces move beyond the element level and incorporate biophilic design on the floor (11/12) and building scale of space (8/12), making them more integral to the design, and thus, more effective at producing positive outcomes.

Global Nature of Biophilic Design. Although only one participant brought up the idea of a global nature of biophilic design, it is important to note that biophilic design does occur in different places for different reasons, and thus the designs tend to differ. This sentiment is clearly stated when one participant notes,

> I think it is worth saying that is is happening in different ways in different places. In the United States, because of a drive for an ever greater level of efficiency and productivity, there is a business drive and we're seeing it in the likes of Amazon, Apple, and Google. In Scandinavia, it is very much part of their lifestyle…it is very much woven into their culture. Then it is happening in the far east, like Singapore and Malaysia, where there is a climate that is very well suited to live like that. (Early Adopter C, Oliver Heath Design, 2018).

In places like Scandinavia, the drive for biophilic design is more innate as it is a part of their typical design ethos. In South East Asia, the climate allows for a more building scale level of biophilic design, with green roofs and walls. In the United States, the drive for biophilic design stems from a productivity or health perspective, resulting in a more interior design focused biophilic design practice. Most vernacular architecture also has a biophilic nature to it.

Knowledge of Resources

The early adopters and the design researchers are knowledgeable when it comes to resources that they can suggest to clients or look at themselves. All seven of these participants were able to list at least five relevant resources in relation to biophilic design, whether it be a printed or digital material, a series of products, or a presentation to view. Two of the participants in these groups have written their own set of guidelines on biophilic design. Four of these participants hold in person educational events, such as design charrettes, workshops, lectures, or conferences.

The group of conventional architects and designers were not as knowledgeable about the resources available to them. Two of the three mentioned that they have very little knowledge of the resources available to them. When asked if they know of research or resources to suggest to clients or view themselves, one responded, "To be honest, no…" but thought it would be "…interesting to read and to look at" (Architect C, Payette Architects, 2018). One of the three conventional architects felt that they had enough knowledge about biophilic design in the healthcare industry that they could pitch it to clients (Designer B, LB Architects, 2018). However, they noted that there should be more resources on incorporating biophilic design in corporate settings, specifically in older buildings in New York (Designer B, LB Architects, 2018). There are resources about this area of biophilic design, so this may be an issue in how accessible these resources are.

Clients

Three themes emerged surrounding how clients influence the use of biophilic design. The first, client-initiated demand, is related to how clients drive the market for biophilic design and is directly related to the second theme, hesitation to sell biophilic design, as architects and designers are hesitant to push biophilic design on their clients. The last theme, previous sustainability interest, delves into the pattern of clients that architects and designers see who demand biophilic design.

Client-initiated demand. Six of the seven early adopters and design researchers stated that their clients come to them and ask for biophilic design. One states, "Increasingly, clients are coming to us…" (Early Adopter C, Oliver Heath Design, 2018). Another says, "Yes, we do. It is not often, but we do" (Early Adopter A, Gensler, NY, 2018). For the conventional architects and designers, this is not the case. All three mentioned that most of their clients do not request biophilic designs. One designer noted that their clients would request it only if it had to do with their brand logo. Another noted that out of all their clients, only one has requested biophilic design. One sums it up, "…the world of architecture doesn't know a lot about biophilic design, so the idea that the client would is, sometimes, even more of a stretch" (Architect C, Payette Architects, 2018). It seems that the early adopters and design researchers fill a niche market for biophilic design, which drives clients to them.

Hesitation to sell biophilic design. For the early architects and design researchers, since the clients are usually coming to them specifically for biophilic design, there is little need to push for biophilic design in projects. Five of the seven early adopters and design researchers do not feel the need to sell biophilic design to their clients as a potential for their projects. One notes,

> It is usually the client who brings it to us…typically not an effective solution for us to suggest it to them…most of the time that is coming from their own initiative, and then it works best that way because then they are actually invested in it, as opposed to you dragging them along. (Early Adopter A, Gensler, NY, 2018).

It can be hard to convince a client to invest in something, so it is much better when the state of biophilic design is client driven.

Three of the seven early adopters and architects felt that they could encourage their clients to request biophilic design. One says, "I've just been telling my clients about it, but they don't know to request it…they're asking for it without knowing they are asking for it" (Early Architect D, Calabrese Architects, 2018). Similarly, another participant notes, "It goes both ways…I think for the most part, a lot of this starts from education, people wanting to learn about what we're doing and how we can help, so that goes inbound and outbound" (Early Adopter B, Delos Ventures, 2018). These two believe that educating the client can be a worthwhile effort.

For conventional architects and designers, two of the three noted that they would not try to sell the client on incorporating biophilic design. One participant sums it up, "I would currently say we are not trying to sell this idea, but if any

manufacturers started to produce really cool projects, we might be suggesting our clients to do that [sic]" (Architect A, Chiang O'Brien Architects, 2018). One of three thought it would be possible to sell the clients on biophilic design, especially if they are interested in a building certification like LEED or the Living Building Challenge. Another interviewee countered that point, saying that LEED and WELL certification is an, "…extra for us, so if anyone wants LEED or WELL we charge extra, and for this reason, clients usually don't go for it" (Designer B, LB Architects, 2018). When asked why, she responded that it is because most people are renting their space in New York City and don't want to pay for a long-term investment that won't pay off (Designer B, LB Architects, 2018).

Previous sustainability interest. According to the interview results, there seemed to be no pattern to the clients that request biophilic design. This may be because, "Anywhere people are present and undertaking some level of activity, there is an opportunity to think about their well-being and how biophilic design can enhance that state, whether it is for productivity, creativity, socialization, or rest and recuperation" (Early Adopter C, Oliver Heath Design, 2018). Three of the seven early adopters and design researchers did mention that clients, from any industry, with a previous desire for sustainability may be more likely to request biophilic design. As one puts it, "…others who have understood sustainability, and perhaps are LEED certified…do tend to understand more quickly the benefits of health and wellness indoors…" (Early Adopter B, Delos Solutions, 2018). Those who are knowledgeable, and desire sustainable design may also be more familiar with current design industry

trends. Since none of the three conventional designers and architects had clients who request biophilic design, this question was not asked to them.

3.2 Practice of Biophilic Design

The next section will detail how the early adopters and conventional architects and designers use biophilic design in practice and which of the categories of biophilic design that they use most. The themes of this section are use, timing in the design process, direct experience of nature, indirect experience of nature, spatial/place-based experiences, and innate vs. intentional biophilic design.

Use. All four early adopters report using biophilic design in practice, although half of the sample mentioned that they use it as a consultant on other design projects. One mentioned, "I definitely use biophilic design in my practice… Part of it is actually explaining to people how to do it, and I think sometimes we try to make it way more complicated than it is" (Early Adopter D, Calabrese Architects, 2018). This confirms that all the early adopters are knowledgeable of and experienced in the practice biophilic design and the process surrounding it. Three of the four reported that they use it in almost all (95%-100%) of their projects, and thus is integral to what they do. One participant states, "For us, it is 100%. It is something that absolutely is a guiding principle in the way that we discuss design or the value of services. It sort of weaves its way into everything" (Early Adopter C, Oliver Heath Design, 2018). The other early adopter could not quantify the percentage of projects that incorporate biophilic design, likely due to his role as a consultant on projects. The difference between how

often biophilic design gets incorporated may also be due to company differences, as those who use it often are in firms dedicated to biophilic design, while the one who uses it less works in a large, commercial design firm with many other focuses.

Out of the three conventional architects and designers, one reported that she never uses biophilic design in practice. She says, "Me specifically, no, not even once. Not even to call out to get plants, not even that" (Designer B, LB Architects, 2018). When asked why that is, she brought up industry standards as the barrier, "It is the industry. It is really hard to get people to spend money on something and to show them that there is value in it…They don't really care about that yet" (Designer B, LB Architects, 2018). She also notes a communication issue, as they are unable to talk to those who care about the human aspect of space, because they work with the facility manager who is focused on the program and less about the human condition (Designer B, LB Architects, 2018).

The other two conventional architects and designers reported using a moderate amount of biophilic design in practice, related to daylight and a material connection to nature in practice. On incorporating natural materials, one says,

> To be honest, I didn't care about it that much before I started really practicing architecture as a profession. Back at school, I did not have a very clear idea of the material selection and nature, or all of this stuff. It was very vague, maybe I had a glimpse of this thought at a certain point, but it was after I entered the profession and saw all of these products and samples, and see them, touch them, feel them, I started to realize the difference it can make, so that is when I started to practice that. (Architect A, Chiang O'Brien Architects, 2018).

Specifically, two of the three mentioned that wood is used in all of their projects. One of the three also mentioned spatial experiences when he said, “But besides the use of wood and daylight, there isn’t much beyond that. I know that our firm has a theory that if you have a long corridor, you want a window at the end of it to have wayfinding…” (Architect C, Payette Architects, 2018). Thus, the practice of biophilic design for the conventional architects is limited.

All three of the conventional architects and designers brought up that, even if they did not personally work on a project with biophilic design, their company has completed projects with biophilic elements before. One elaborates,

> My office has…on a project where, it is kind of like a WeWork space, so because they’re having so many people come in that are different and they want to entice people to stay, that is why they were willing to do something different, so they put a green wall that went from the first story to the second story. (Designer B, LB architects, 2018).

This means that there is some demand for biophilic design in the conventional architecture and design field, however it is usually driven by the demands of a unique client.

Timing in the design process. When asked about when biophilic design comes up during the design process, two of the four early adopters and one of the design researchers said that it comes up in the early design phases, as seen in Figure 3.12. One said,

> I would say the programming and conceptual phases, because well, it should. I think effective biophilic design has to come up in both those phases. The programming is where you set you intent for a project and the type of spaces that support that intent. To do proper conceptual design, you have to understand your ecology, geography, and geology… so those decisions come in really early. (Early Adopter D, Calabrese Architects, 2018).

Another notes, "When we do get a project, we do research about it and look at what precedents might be out there, and how we might implement biophilic design in different ways" (Early Adopter C, Oliver Heath Design, 2018). The other two participants act as consultants, so when they join projects is out of their control. One notes, "It depends, it varies per project, but, on good projects, very early, and on other projects where we are less effective, later" (Early Architect A, Gensler, NY, 2018). Another participant mirrored this notion when saying, "I would say that the later biophilic design is introduced in the design process, the less biophilic a space is" (Early Adopter D, Calabrese Architects, 2018). It seems that timing is key to how effective biophilic design is, as earlier integration leads to very intentional biophilic design, whereas later incorporation of biophilic design is less thought out and integrated into the entire project.

For the conventional architects and designers, biophilic design tends to come up in the later phases of the design process, as seen in Figure 3.12. Two out of the three conventional architects state that it comes up at the end of schematic design, after floor plans are drawn up and it is time to specify materials. They also note that

they might have vague idea of the look and feel of the space earlier in the process. For example,

> We might have a general idea of the feeling of the space that we are trying to create. So, at that stage we will probably have an idea that we want a lot of wood elements on this side or not, or that we want a more modern look. But really thinking about it seriously is maybe at the end of the schematic design phase, when we need to really specify the materials and show it to the client. (Architect C, Chiang O'Brien Architects, 2018).

One of the three conventional designers noted that biophilic design is viewed as an add on, "…it wouldn't come in our programming document, it would come up in the section of extras, at the end, like any special requests, something like that. It is not a general question we have one our programming document" (Designer B, LB Architects, 2018). The idea that biophilic design is an add on means that it is not integral to the entire design.

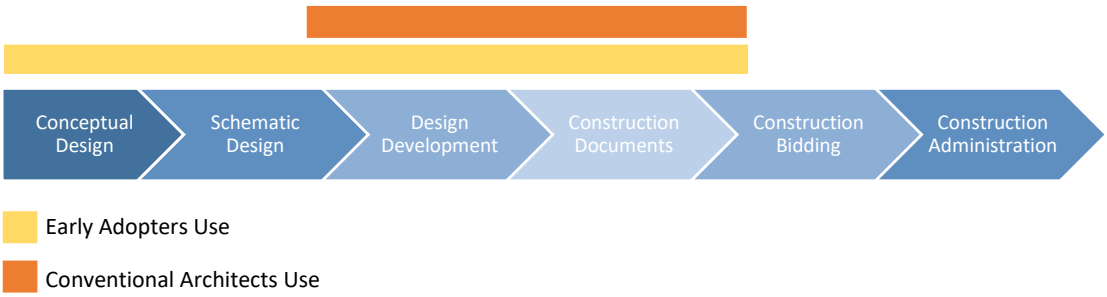

Figure 3.12. When Biophilic Design is Incorporated in the Design Process. Yellow represents when early adopters use biophilic design, orange represents conventional architects use it.

Direct experience of nature. All four of the early adopters say that they use a direct experience of nature in their work and that it is used in all of their projects. One says,

> Yes, this is the one thing that everybody knows, the real direct experience, the sensorial experience that people can see, which is fundamental to biophilic design, and it is obviously the one that has had the most amount of research that demonstrates its values and its potential to improve. This is the one aspect people think of when you talk about biophilic design. (Early Adopter C, Oliver Heath Design, 2018).

Another respondent touches upon how some strategies are used more than others in this category, "So it varies, right? Access to daylight or access to views is going to be something that we, or most designers, would prioritize these days…it is something that we know has a really strong correlation with well-being", but also discusses that integration of greenery comes with a cost that makes it less common (Early Adopter A, Gensler, NY, 2018). This shows how there is a spectrum of how a direct experience of nature can be included in a design process. Certain elements, such as daylight and access to windows, are used more than incorporating plants, water, or natural scents and sounds.

All three of the conventional architects and designers say that they have incorporated some of the patterns of a direct experience of nature in their designs. The most commonly used strategies in this category are daylighting (3/3) and access to windows (3/3). They use this because it is a **'**normal**'** aspect of architectural design, "[When discussing biophilic design before], I was thinking more of those cool applications [green walls], but I was kind of neglecting the windows, the introduction of light, all of this stuff, which I consider just normal, you know" (Architect A, Chiang O'Brien Architects, 2018). None of the four conventional architects and designers

mentioned natural sounds, scents, or thermal variability. One designer had worked on one project with a green wall.

Indirect experience of nature. All four of the early adopters have used an indirect experience of nature in their projects. They note there is ample opportunity to incorporate an indirect experience,

> the opportunities to bring nature inside can sometimes be really limited, with all sorts of restrictions and perceptions. But, when we are thinking of putting materials into a building, whether it is floors, walls, ceilings, we have an opportunity there to start thinking about bringing in some natural analogues because we are going to be putting something in anyway. (Early Adopter C, Oliver Heath Design, 2018)

Three out of the four early adopters mentioned carpet, and two specifically mentioned Interface Carpet, as a way to incorporate this form of biophilic design. Three out of four also mentioned natural materials and finishes to incorporate this design. Three of the four also mentioned that more manufacturers and products are being produced for this category**.** One states, "…technology is allowing us to produce ever more realistic, convincing analogues of nature…so, we are seeing a real interested in manufacturers getting on board with this idea of biophilic design" (Early Adopter C, Oliver Heath Design, 2018). None of the early adopters mentioned using biomorphic forms.

Two of the three conventional architects and designers say they use wood in 100% of their projects. All three mentioned that the carpet industry is creating products that evoke a connection to nature and they use them in their projects. One

notes, “These are getting more trendy in finishes, like carpet, because we have vendors come in to show us the newest carpet every week. It looks like the industry is going towards organic, natural shapes and the carpet looks like that too” (Designer B, LB Architects, 2018). Two of the three specifically mentioned Interface Carpet. Two of the three also mentioned natural finishes as a way that they incorporate indirect experience to nature in their projects.

Spatial/place-based experiences. All four of the early adopters have used this type of biophilic design in their practice. All four of the early adopters noted prospect and refuge as spatial experience that they create in space. One of the two design researchers confirmed that prospect and refuge is seen a lot in practice. Three of the four noted that there is room for growth in this category. One states, “Again, I still think that more can be done to really think, organizationally, how you navigate a space in terms of these principles…Sometimes it happens in our projects, sometimes it doesn’t” (Early Adopter A, Gensler, NY, 2018). One also noted that the category “has the potential to be expanded upon the four [patterns]…a sense of community is really important as well. Whether that is a missing factor within the 14 Patterns, I don’t know. But, I am very passionate about the idea that nature can enhance the sense of community…” (Early Adopter C, Oliver Heath Design, 2018).

This notion was confirmed by one of the design researchers,

> We are working on a new pattern that a number of folks have been talking about and working with us for years. We are still trying to gather enough

> science to quantify it best, but it is a spatial experience called awe. (Design Researcher A, Terrapin Bright Green, 2018).

Thus, while spatial/place-based experienced are used in the early adopters' practice, there is opportunity to do more with space.

Responses of how conventional architects and designers use this category of biophilic design was mixed. One out of the three mentioned that she did not use it at all. One of the three said it was used "weakly" in design. One out of three was baffled by the concept, especially peril, which was laughed at, but once it was explained, realized that prospect-refuge was used in many projects.

Innate or Intentional? This last pattern is one that has emerged multiple times from the participants. This theme has to do with what defines biophilic design. Is it a design ethos that is driving all design decisions or is it a series of elements, strung together that can make a whole? As seen above, all of the conventional architects and designers have used biophilic design in their projects through daylight and natural materials, whether they intended to or not. The question is, does it matter if biophilic design is happening innately or does it need to be an intentional process? One of the four early adopters and one of the two design researchers believe it is acceptable if biophilic design is happening innately in design. He states, "It is a hard concept to be able to convey to designers. I think that most of them, when you start talking about it, already feel like they do it to a certain degree. So, I would say there is a real reluctance for anyone to sit down with a framework and be like did I cover this, or this, or this?" (Early Adopter A, Gensler, NY, 2018). Another notes,

> there has been validation and inspiration with design. I'm personally okay with validating; other people just want it to be truly inspirational. I think biophilic design can be validation, like 'Oh, we did this or that, and it coincides with biophilic design'… It's not necessarily helpful, but I think its fine. There's a lot of that going on (Design Researcher B, ILFI, 2018).

Two of the four early adopters believe that biophilic design should be intentional, but innately using it is a step in the right direction. One of the four early adopters felt that biophilic design must be an intentional process, when stating,

> It is not a checklist approach, it is telling us what is important. It is like ingredients for a great meal, for a great healthy meal and you can decide on which ingredient to use to create the meals that you want to create. (Early Adopter D, Calabrese Architects, 2018).

She is stating two things in this quote. The first is that metrics for biophilic design may discourage true biophilic design. The second is, like cooking a recipe, designers can choose which elements to incorporate, but they must have the final outcome in mind when they do so.

3.3 State of Standards

According to two of the three design researchers, biophilic design standards at the moment are largely narrative, with an option for a quantitative metric of biophilia found in the WELL Building Standard (Design Researcher C, IWBI, 2018; Design Researcher B, ILFI, 2018). The narrative of biophilic design does not, at the moment, require a post occupancy evaluation to ensure that it is properly implemented, however

the plan is reviewed by a third party. The ILFI promotes a one-day visioning session that asks the relevant stakeholders to think about how biophilic design can improve their projects.

In both the Living Building Challenge and the WELL Building Standard, there are no set requirements for specific biophilic design elements. The certification systems encourage looking at light, space, and place, however, the mandates are satisfied if some of Stephen Kellert's Principles of Biophilic Design or Terrapin Bright Green's 14 Patterns of Biophilic Design are incorporated.

In the WELL Building Standard, there is an option for an optimization. This requires that the space have a specific percentage of green walls and water features throughout the space. The representative from IWBI noted that this optimization does not occur frequently in the certification process. She states, "…the optimization is less frequent, people less frequently go for that. And I think there's a couple of reasons why… a lot of it has to do with operations and costs" (Design Researcher C, IWBI, 2018).

3.4 Barriers to Implementing Biophilic Design

The building industry has various risks associated with it. The most salient of these risks is a financial one. However, incorporation of biophilic design may be perceived as a risk because it is relatively unknown in the industry. This "risky" perception influences some of the other barriers to the practice of biophilic design. Throughout the interviews, several barriers were mentioned that limit biophilic design in practice. These will be discussed through six emergent themes that consolidate the

barriers. The six themes are clients, knowledge and understanding, communication, integrity of biophilic design, accessibility, and value proposition.

Clients

There are various stakeholders who serve as clients of design professionals. These stakeholders impose barriers on the professionals themselves in a variety of ways. The barriers in this category are out of the control of the design professional, but are important limitations to biophilic design that must be addressed in the future. These barriers include cost, maintenance, space, and industry trends.

Cost. This barrier was mentioned several times throughout the interview process. All of the early adopters and conventional architects mentioned cost at one point or another as a deterrent of biophilic design. Six of the ten (three early adopters and three conventional architects) felt that cost was a barrier to implementing direct experiences of nature, especially greenery, as it has both a high initial cost and maintenance cost over time. For example, "When you start to get into integration of greenery…or water features, now you are starting to talk about additional cost and additional operational and maintenance cost, which is probably the biggest deterrent to those types of solutions…" (Early Adopter A, Gensler, NY, 2018). Two of the four early adopters mentioned cost as a barrier to implementing indirect experiences of nature. One of these two noted that biomorphic forms are large installations, which makes them costlier than other elements. Two of the three conventional architects felt that cost was a barrier to including indirect experiences of nature in design. Since cost

is such a salient barrier, it must be addressed to increase the practice of biophilic design.

Maintenance. Beyond the maintenance cost, the effort involved in upkeeping biophilic design elements is a different kind of barrier. One of the four early adopters and two of the three conventional architects felt that maintenance efforts prevented clients from investing in biophilic elements, like green walls or water features. One clearly states, "Maintenance is the bigger issue [than cost]. If there is technology that will take care of all of it and they [client] don't have to invest in another person…I would say the barrier will be reduced significantly" (Architect A, Chiang O'Brien, 2018). Another noted that patterns and textures are harder to upkeep over time, because they are more difficult to clean and if one area gets ruined, it may be necessary to replace the entire feature, like a textured wall for example (Architect C, Payette Architects, 2018).

Space. The actual, physical space of a design project may also be a barrier to biophilic design. Four of the ten respondents (three conventional architects and one early adopter) mentioned space as a barrier. Depending on where they are located, buildings and urban environments may limit the quality and quantity of nature available to integrate into a design. One participant brings this up when stating,

> When we do projects in the middle of London, the street widths are very narrow, there may only be four to five meters between one building and another…very little direct light…In the urban environment, the opportunity to

> implement direct experience may be limited because space is so limited and so dense… (Early Adopter C, Oliver Heath Design, 2018).

When access to nature is limited by the surrounding environment, it becomes even more important to incorporate it into the interior, whether on an element or floor scale.

Another spatial barrier is the program of the space, as many see biophilic design as a means to induce restoration. Two of the three conventional architects mentioned this barrier. One states,

> if you don't have the opportunity to create [a gathering space], you're unlikely to incorporate it [biophilic design] into a workspace because your workspace is different from your relaxation/gathering space. It is more serious and toned down, so you don't have that opportunity. (Designer B, LB Architects, 2018).

These participants felt that biophilic design was limited to gathering spaces.

Lastly, space may be a barrier if the project is not a new building, as there are already spatial and structural elements in place. This is more of a barrier to spatial/place-based experiences, which can be seen when one participant says,

> we do a lot of renovations, so that is actually a limit to practice this third category [spatial experiences] because the envelope is, kind of, already defined. We do have some limits, like sometimes we wouldn't do such a huge gesture in trying to change the layout and try to open it up to create a special room just for experience (Architect A, Chiang O'Brien Architects, 2018).

Thus, the project space itself may be a barrier to specific types of biophilic design patterns.

Industry trends. Trends in the industry can dictate how biophilic design is implemented in two ways. First, it can influence the way design professionals go through the design process. Trends can dictate whether the focus of design is on space efficiency, energy efficiency, or human health. At the moment, although the trend of health is gaining momentum in the industry, there is also still a more space-centric approach to design that is occurring. Most people are interested in seeing how many people they can fit in a space, rather than the human condition of the space. One of the participants summed this up when stating,

> I would say that the industry of design and architecture is often focused on how many people you can fit into space and still allow them to be comfortable enough to work every day…that is still where a lot of people stand, instead of understanding what is best for those individual people and maximizing their performance. (Early Adopter B, Delos Ventures, 2018).

The second way that trends influence design is by reaching clients. Two of the three conventional designers mentioned that if biophilic design became a more prevalent feature in architectural projects, clients would be more likely to request it. Clients tend to decide what they want in their space based on industry trends. For example, one participant states,

> similar to how social pressure works in groups, I think there's also a movement of the industry itself. People won't do it until everyone is doing it…clients don't want to do it, they don't want to do something no one else is doing, they don't want to look like a sore thumb. But once they see everyone doing it, they'll want it too. (Designer B, LB Architects, 2018).

She also mentions an example in the law industry, how "mock courtrooms are really big right now…all the law firms are coming back to us saying, 'we heard this is the new thing, so we want it'. So, wouldn't it be great if they're like, 'hey, biophilia is in, let's do it!'" (Designer B, LB Architects, 2018). Thus, there needs to be more volume of biophilic design projects to drive clients to demand biophilic design.

Knowledge and Understanding

Biophilic design is a relatively new field that has only reached the public for ten years or so. Thus, knowledge of biophilic design, how to implement it, and how to properly understand it, is still a challenge for many design professionals and clients. This section will discuss barriers to the practice of biophilic design in the sense of misconceptions about biophilic design, professional understanding of biophilic design, and multiple stakeholder understanding of biophilic design.

Misconceptions. Architects and designers bring their own notions of what biophilic design is when they consider using it. There are certain aspects of biophilic design that conventional architects seem to misunderstand. For example, in all three of the interviews with the group of conventional architects, each of the respondents at one point or another stated something incorrect about biophilic design. For example, one noted, "We just had a dermatology office project…it is a local clinic and that owner was showing a little bit of interest in it [incorporating nature]. She was thinking of putting like a fish tank, not like so very biophilic" (Architect A, Chiang O'Brien Architects, 2018). Including elements of water and living creatures into a space

definitely falls under biophilic design. Other confusion surrounding spatial experiences, thermal variability, and visual access to nature arose as well.

Another misconception is that biophilic design is limited to only gathering spaces. All three of the conventional architects mentioned that they would not use it in an area where work is accomplished, however this limits the type of biophilic design that can be implemented. One notes, "…you're not likely to incorporate it into a workspace right because your workspace is different than your relaxation gathering space so it's more serious and like toned down, so you don't have that opportunity. That's definitely a barrier to incorporating things that might be more intrinsic and interesting" (Designer B, LB Architects, 2018). Another echoes this notion stating,

> It tends to be mostly focused on the public spaces, which can have more daylight and larger areas. It may be specific to a type of work we do but because we do a lot of lab or medical spaces, the actual lab areas need to be pretty heavily sealed off sometimes, for research purposes. (Architect C, Payette Architects, 2018).

This idea that biophilic design is constrained to gathering and collaboration spaces is unique to the group of conventional architects.

The early adopters noted that there are also misconceptions about the intent of biophilic design. Three of four early adopters believe that the barriers to incorporating spatial/place-based experiences seem to focus around a misunderstanding of biophilic design in both the design professionals and clients. One notes,

> I think this human aspect is still the one thing that people are finding difficult. It is really about how we connect people to direct or indirect references of

> nature as a means to create aspirations, stimulating, energizing, exciting spaces, or by contrast, restorative and recuperating spaces… People who don't know very much about biophilic design just go, 'oh, it's all about plants, nature, greenery, and natural materials', but really, it is about people…It is one think that I think is often missing from projects that proclaim themselves to be biophilic. (Early Adopter C, Oliver Heath Design, 2018)

He even mentioned that people "start laughing" when peril is brought up as a pattern. This was confirmed in one interview with a conventional architect.

Professional understanding. Beyond misconceptions, some professionals need to broaden their knowledge and understanding of biophilic design, both conceptually and in practice. This was a barrier that was brought up by all ten interviewees. All three of the conventional architects mentioned this as a barrier to implementing either a direct or indirect connection to nature. For example, one participant noted that knowledge of what colors, patterns, textures, and shapes are effective at eliciting positive outcomes would help designers make decisions about how to specify biophilic finishes. Another states, "Designers also need to be educated on the new products, the idea of nature, and how it will impact your design" (Architect A, Chiang O'Brien Architects, 2018). Two of the three conventional architects noted that education may be a mediator to the cost barrier, as it would reduce change orders and clarify the return on investment. However, many architects and designers are not knowledgeable about biophilic design yet, so it is also a barrier. One described her experience in building a green wall,

> When we put up that green wall, we thought it would be easy. It is hard to build and have plants growing on them…there is just so many things we did not know, like we had to put in a humidifier…we had a wood floor, it affects that, do you walls have a moisture barrier? No, go fix that now. It creates a lot of change orders. (Designer B, LB Architects, 2018).

There seems to be a learning curve of biophilic design, confirmed by another participant who raised the concern that designing and constructing organic and biomorphic forms is difficult, even with computer aided design. It requires education and practice, which will be discussed in detail in the barrier of education.

Multiple stakeholder understanding. Beyond the understanding of design professionals, it is also important that the clients and multiple stakeholders on the projects, like facility managers, chief financial officers, and developers have a shared understanding and knowledge of the value of biophilic design, especially since most biophilic projects must be specifically requested by clients. Two of the four early adopters noted that client education and potential misunderstanding of space are barriers. Similarly, one felt that clients tend to have trouble understanding space, so they cannot see the potential of what is there (Early Adopter D, Calabrese Architects, 2018).

Communication

These barriers relate to how biophilic design is communicated between the designer and the client, as well as the client with various stakeholders.

Client-designer communication. There seems to be two issues surrounding communication between clients and designers. The first is the hesitation to sell biophilic design to the client, as mentioned in the previous section. The conventional architects are hesitant to push their clients towards biophilic design solutions as they are afraid of not winning request for proposals and losing business. The second issue is communicating with the wrong stakeholder. One conventional architect mentioned that their point of contact is usually the facility manager, who cares less about the human condition of the space. On the facility manager,

> It's not in their job to think about the well-being of the employees, it's more, just like, the hard-cold facts of, 'well we have this many people, we're going to grow 5 percent in two years'. And it's nothing about, 'well you know our employees don't seem happy'. They're not that people. We don't talk to human resources, who might be able to give us that information and we don't talk to the CEOs or the VPs or anything like that who might be able to give us better design direction. We're usually pitching facility managers. (Designer B, LB Architects, 2018).

This point of contact prevents a human-focused design direction.

Client-stakeholder communication. Like the previous barrier, client stakeholder communication is about ensuring that all of the primary stakeholders understand the value of biophilic design and are invested in it. Two of the four early

adopters and one of the three conventional architects found this to be a barrier to biophilic design adoption. One describes this example,

> There is often a lot of interest initially [in greenery], when those ideas are proposed, and then when you get into the value engineering process in our projects, those are oftentimes the first things that get cut. The reason for that is that they are not integral to the design of the project and they are seen as an add on, so they are easily excluded when it comes to the point of evaluating whether or not they need them. Most of our projects go through a VE process at one point or another. (Early Adopter A, Gensler, NY, 2018).

This is very similar to what another early adopter said,

> So, whilst the immediate client in front of me may go 'we love plants, it's great, we want to do all this', once the designs go in front of a surveyor or CFO and they turn into a spreadsheet, what this person is seeing is a massive number next to plants and greenery … they go why are we spending this money on greenery and plants? Forget it, look at what a great job I'm doing by cutting budget, I've chopped all those plants out, so we don't need those anymore. (Early adopter C, Oliver Heath Design, 2018).

Communication between these stakeholders may prevent biophilic design from being cut from projects.

Accessibility

Accessibility of resources and research is another large barrier to the practice of biophilic design. Design professionals must be able to access resources to learn and

understand the field. Three barriers emerged from the interviews related to accessibility. These are resources and dissemination, language of biophilic design, and education.

Resources and resource dissemination. All of the ten participants agreed that there needs to be more resources on biophilic design and how to practice it. Three of the ten respondents felt that the resources that are available at the moment, in print, need to clearly communicate the outcomes of biophilic design, as well as teach people how to use it correctly. Summing this argument up clearly, one participant said, "…how do people get easy access to it and build it into a program where they can learn more and deepen their practice…" (Design Researcher B, International Living Future Institute, 2018). Another participant agrees with this when he states,

> I think this probably goes across the board for all biophilic design that, even though there has been a great effort on the part of a few people to really make this a science, there is still no formula of delivering a successful biophilic design…people are looking for a guideline about what they need to put into their project or not and there is no 'you do this, you get that out of it' and to be able to explain that to clients in a clear way is very difficult to do. (Early Adopter A, Gensler, NY, 2018).

There needs to be more resources that teach architects and designers how to use biophilic design more effectively. Additionally, the way that these resources are presented may be a barrier themselves. One of the four early adopters made this clear when he stated,

> The other thing, when you do a search for biophilic design, I think Terrapin did a good job of packaging their stuff, but if you look at Kellert's stuff, it looks kind of old and antiquated. So, I think a packaging of this that is modern and aesthetically appeals to design professionals would be a key piece. Architects and designers, they like pictures, and strong visuals so whatever it is think about that and graphic design. (Early Adopter A, Gensler, NY, 2018).

This idea of understanding the audience of resources is key to ensure that they actually use them. Beyond printed material, in-person events such as, lectures, lunch and learns, design charrettes, and conferences exist, and five of the seven early adopters and design researchers actually lead them. However, both the printed and in person resources have not reached any of the conventional architects, besides lunch and learns hosted by Interface Carpets on their biophilic patterns. In fact, all three of the conventional architects noted that they want more resources that have case studies, specifically about corporate interiors, information on the history of biophilic design, and in-person educational events. For example, one states, "Oh my God, why is there nothing on corporate interiors? For existing buildings, not like, 'we're going to build a new building, we'll put all these huge windows in and a park'", she wants examples of

> just like, normal offices. New York City has such a huge amount of square footage. And so, this is the real world that's actually happening. I think those other resources, they're great for like California and places that have more opportunity. But New York has so many restrictions and it's so hard and were limited a lot. So, I would love to see something for buildings like that. (Designer B, LB Architects, 2018).

However, these resources exist, so dissemination of resources seems to be a key barrier to the accessibility of biophilic design information.

Language of biophilic design. The origin of biophilic design is largely from a scientific perspective. Research on biology, evolutionary biology, human physiological, psychological, and cognitive outcomes are found when searching for biophilic design. Thus, the language surrounding biophilic design has become its own barrier, as research translation has not necessarily toned down the scientific nature of the field. One notes, "It's a matter of finding the right context and the right moments to share that kind of information" (Design Researcher B, ILFI, 2018). Four of the ten respondents, two early adopters, one design researcher, and one conventional architect felt that the language surrounding biophilic design is a barrier. Specific issues with the wording of spatial/place-based experiences was mentioned twice, for example,

> I think there's some things that get lost in translation from like, academic biology speak, into the design world. And those tend to be harder, information complexity/density, things that people are like, 'those words sound fuzzy'…some of these are a little bit esoteric. (Design Researcher B, ILFI, 2018).

Another noted that simply saying biophilic design is enough to have "people just start to glaze over" (Early Adopter A, Gensler, NY, 2018).

Education. There are three scales that professionals can be educated about the biophilic design practice. The first is in school, where people can be introduced to this

very early on and get a deeper conceptual understanding of biophilic design. There may also be a chance to practice this design on school projects and learn through experience, which is the second type of education. Design professionals who can work under experts in biophilic design will simply learn the practice by observing and contributing to biophilic design projects. The last way to educate is through a third party, who either creates resources or leads educational events.

The interviewees focused on third party education opportunities in their responses. Education as a barrier was brought up by all of the ten respondents. One states, "…your hurdle is education, your hurdle is having people who understand. Not only are you educating the client, who wants to implement this type of design, but you're also education the architect who has to actually properly implement it…" (Early Adopter B, Delos Ventures, 2018). Beyond education on the concept of biophilic design, two of the four early adopters believed that knowledge of products is key to implementing biophilic design.

Integrity of Biophilic Design

Biophilic design is thought to be more than just a use of elements that evoke a connection to nature. Rather, it is a design ethos, that drives every part of the design process. This integrity of biophilic design as an ethos, instead of as a framework that designers can look to may be a barrier to use. Other aspects of the rigor of biophilic design, like timing and the fact that it is about creating a connection to natural systems and processes is also a deterrent to use.

Design ethos. Biophilic design is thought to be a design ethos to six of the seven early adopters and design researchers. This means that it is an overarching process, guiding design decisions. However, the conventional architects tend to incorporate biophilic design as it comes up in the design process, and do not think about it holistically. The notion that it is a design ethos may be deterring conventional designers from using it, if they feel they don't have the knowledge or the time to devote to a holistic biophilic design process.

Connections to larger natural systems. In a similar vein to the last barrier discussed, biophilic design is about more than just incorporating natural elements into a space. There must also be a focus on integrating larger natural systems into the projects. All four of the early adopters feel that this is important to biophilic design. For example, one states,

> I think sometimes people don't understand that biophilic design is about those connections…if you totally, absolutely embrace them, then everything uses less energy, it is more balanced, and there's harmony…natural systems and processes are so powerful and have their own abundant energy if we just allow them to. (Early Adopter D, Calabrese Architects, 2018).

However, the conventional architects never mention a connection to larger systems and processes, thus this is a barrier to implementing proper biophilic design in practice.

Timing in the design process. As mentioned in the previous section, the time at which biophilic design is introduced limits the effectiveness of the design. Two of the four early adopters noted this barrier, exemplified by the quote, "I would say that the later biophilic design is introduced in the design process, the less biophilic a space is" (Early Adopter D, Calabrese Architects, 2018).

Value Proposition

The last set of barriers relate to the value proposition of biophilic design. Right now, the known value seems to be lacking because it is seen as not integral to a project, the nature of the outcomes is hard to quantify, and the value is not properly communicated.

Biophilic design is not integral. Throughout the interviews, five of the ten respondents noted that their clients feel like biophilic elements are not integral to the design project, but rather are viewed as an add on. One notes, "…those [plants] are oftentimes the first things that get cut…[because] they are not integral to the design of the project and they are seen as an add on…" (Early Adopter A, Gensler, NY, 2018). Another mentioned that is would be discussed as a special request, not a vital element to the program (Designer B, LB Architects, 2018). It is hard to convince a client to invest in an element that they do not find integral to the project.

Nature of outcomes. A reason that biophilic design is viewed as an add on may be because of the nature of the outcomes of biophilic design. Many of these

outcomes are ‘intangible’ or ‘invisible’ according to the interview respondents, and thus they are unaware of the benefits, both in terms of health and well-being and monetary value. Seven of the ten interviewees expressed this concern during the conversation, mentioning that it is hard to discuss the value of biophilic design when the benefits are difficult to see. One early adopter states,

> I think part of the education becomes making the invisible, visible to a certain degree…from a design perspective and a product implementation perspective, unbeknownst to you, I’m creating a healthier person…to deliver passive wellness is really important, and if there is somebody who gets it in that building, who understands the benefit that it has on people, understands the benefit they’re going to have on company productivity, then they’ll understand it and be able to help other people in turn. (Early Adopter B, Delos Ventures, 2018)

These participants also note that research and examples of biophilic spaces that clearly prove tangible outcomes will diminish this barrier.

Communication. Lastly, communication is a large barrier to promoting biophilic design practice. Three of the ten participants felt that clients do not respond well to scientific outcomes. Instead, monetizing the benefits would push them to invest in biophilic design. It also became clear in the interviews that framing biophilic design in a way that makes it personal to others is more effective than other kinds of communication. Five of the ten respondents felt this to be true. One notes, “…I think it is really important to get people to understand that the connection to nature is within

themselves…[we need to help] people understand that desire to be connected to nature is within each of us…but more than that, it is important to the people around us" (Early Adopter C, Oliver Heath Design, 2018). To prove this point, one third of the respondents mentioned a personal connection to nature when discussing the value of biophilic design, as stated in the previous section.

3.5 Promoting Biophilic Deign

This last section will discuss how the participants responded when asked what is needed to promote biophilic design in the future. Three themes emerged, resources, future research, and creating value, which will be presented below.

Resources

It is clear that the conventional architects desire more resources, as all three asked for them. Specifically, conventional architects and designers asked for more examples of successful applications, guidelines in how to practice biophilic design, and in-person educational events.

Successful applications. In addition to the three conventional architects, all ten of the respondents felt that the best way to promote biophilic design to other design professionals and clients is through examples of successful applications. Nine of the ten respondents mentioned that more case studies would entice professionals to try biophilic design. One conventional architect notes, "I think successful projects will be really helpful and that is most likely what we will bring to our clients to show

them…then I think it is very easy for us to sell the idea" (Architect A, Chiang O'Brien Architects, 2018). An early adopter states,

> professionals respond to successful applications, and when I say that, I mean, case studies are important but also, showing that projects have won awards…It is easy to get designers' attention and design professionals' attention and say, 'this is a recognized notable project', and then people want to replicate what was done there. (Early Adopter A, Gensler, NY, 2018).

Case studies in all industry type would be great, especially corporate workspaces (Designer B, LB Architects, 2018).

Guidelines for practice. In addition to more case studies, one of the four early adopters and all three of the conventional architects feel that there is a need for guidelines on how to practice biophilic design. When asked if any resources are missing, the early adopter responded, "I do! And, it is what I am working on. It is about the process; how do you actually implement it. Understanding how to integrate these systems and processes biophilically, is missing" (Early Adopter D, Calabrese Architects, 2018). The conventional architects agreed with this notion, one states, "…once that basic understanding is there, then going to another level and saying, 'how do you design for these things?'" (Architect C, Payette Architects, 2018). Guidelines need to be "…simplified into a single document so that people can understand it very comprehensively and quickly", this "would probably be a good thing" (Early Adopter C, Gensler, NY, 2018). These participants believe that a set of guidelines on how to

practice biophilic design that is simple and comprehensive will promote biophilic design in a stronger manner.

In-person educational events. Beyond looking at successful applications and printed guidelines on how to practice biophilic design, all seven of the early adopters and conventional designers believe that in-person educational events will promote biophilic design to professionals. One of the design researchers agrees, stating that, "Hands on learning is always better, in any part of education" (Design Researcher A, Terrapin Bright Green, 2018). Two of the early adopters and all three of the conventional architects thought that design charrettes would be a good way to educate professionals on how to use biophilic design. One conventional designer thinks that,

> lunch and learns, not from people who spec finishes, like I don't want my carpet guy to tell me about biophilia…. I'm like, why isn't there a researcher who has like qualifications working from WELL coming to just tell us…about the wonderful implications that this could have. (Designer B, LB Architects, 2018).

Future Research

Five of the seven early adopters and design researchers felt that more research could be done in the field of biophilic design that may promote future use. Three of the five were interested in human responses to biophilic design in space, specifically looking into psychological and physiological responses, as well as neural cartography and human markers. Two of the five think that studying individual biophilic design elements and understanding their specific outcomes on human well-being and

performance would be useful research. For example, "…each attribute you could do an entire study on just that one attribute, like what does lighting do? What does discrete lighting do? What does dappled lighting do?" (Design Researcher B, ILFI, 2018). Lastly, one of the five suggests that more pre and post occupancy evaluations that are qualitative in nature and focused on satisfaction and affect would demonstrate the value that biophilic design holds.

Creating Value

The last section discusses how to create value for design professionals and clients through a personal narrative, emphasizing visible outcomes, and creating a new normal of biophilic design.

Personal narrative. As stated in the earlier sections, using a personal narrative to create a connection to nature is thought to increase the value of biophilic design. Six of the ten respondents felt that framing biophilic design this way could promote more use in the future.

Visible Outcomes. Again, the idea of demonstrating the outcomes of biophilic design in a manner that is visible was mentioned by seven of the ten participants. This means showing increases in productivity, health and well-being, and affect and satisfaction. Two conventional architects noted that, "Also trying to monetize the benefits to some level" would drive clients to value biophilic design (Architect C, Payette Architects, 2018). One notes,

you could provide them some numbers, like before and after. Like before, what is the annual sale and after you introduced biophilic design, has the number changed? Did that attract more consumers? I think that will be the strongest support too for clients. (Architect A, Chiang O'Brien Architects, 2018).

Creating a new normal. All three of the conventional architects believe that if biophilic design could become the norm of the design industry, practice and demand for it would increase. They believe this can be accomplished in small steps, as one states, "I mean, you said that Living Building Challenge and WELL both focus on them heavily, if you can get it in something more common, with LEED buying into it as well, then it very much brings it to the forefront." (Architect C, Payette Architects, 2018). They believe that creating a trend for biophilic design will lead to an increased integration of it into design projects.

4. Discussion

Clearly, as seen in the data, the current practice and barriers of biophilic design are extremely nuanced. This next section will discuss the current practice of biophilic design, the barriers to practicing biophilic design, and how to address them to promote diverse elements of biophilic design in practice.

4.1 Current State of Biophilic Design

The data on the current state of biophilic design is clear. Early adopters and design researchers are extremely knowledgeable about the field and regularly practice an all-encompassing biophilic design ethos when they work on their own projects.

When the early adopters are consultants, they are at the whim of the design team that they are consulting for. It is also understood that the conventional architects and designers know less about biophilic design than the early adopters, as seen in how they define and understand biophilic design to be. This group of professionals either do not use biophilic design at all, or they use a less precise or intense version of biophilic design, generally bringing in a material connection to nature or incorporating daylight without thinking about the space's connection to larger natural systems.

Clients

Additionally, the clients for each of these groups are distinct. For early adopters and design professionals, the majority of their clients seek them out specifically to do biophilic design. For this reason, there is very little need to sell biophilic design to their clients, as they already understand the value of biophilic design, whether it be for health reasons, productivity reasons, or a desire to reconnect to nature. However, for the conventional architects and designers, only a rare, unique client would demand biophilic design, and thus, their projects do not tend to incorporate biophilic design into them. They also are very hesitant to push biophilic design on their clients, as they do not want to lose the request for proposal or drive their clients away. This is important, because if no one is demanding biophilic design and no one is willing to sell biophilic design, the chances of it being incorporated in practice is slim. From this point alone, there ought to be a strong value proposition that clients demand and designers can easily sell, without seeming to be too pushy.

Timing in the Design Process

In terms of how they use biophilic design in practice, there are many differences between the early adopters and the conventional architects and designers. The first is when biophilic design is integrated into a design project. For early adopters, biophilic design is a driving principle that emerges in the early design phases of conceptual design and programming. During these stages, the intent for the rest of the project is set. Thus, when biophilic design is included at this point, it is clear that the design professionals are thinking holistically about how biophilic design can be achieved at a higher, more effective level. The conventional architects, however, incorporate biophilic design at a much later stage in the design process, as the majority say it is included at the end of schematic design, when it is time to specify materials. The issue is that, by this time in the process architectural massing and floor plans are complete. If biophilic elements are incorporated at this point, it is unclear if they will be placed in locations that create the most engaging and continuous presence for occupants, meaning that they may be less effective at creating beneficial outcomes. Furthermore, at this point in the design process, the ways to incorporate a spatial/place-based experience of nature is limited as the schematic plans are finalized.

Use of Biophilic Design

In terms of incorporation of the three categories of biophilic design, differences emerged again between the early adopters and the conventional architects. The early adopters, who are not consultants, use all three categories of biophilic design, a direct experience of nature, an indirect experience of nature, and

spatial/place-based experiences in all of their projects. In projects where one of these categories is not possible, they maximize use of the other types, ensuring a biophilic space. For those of the early adopters who act as consultants, a spectrum of biophilic design elements are included in their projects. For example, daylight, access to views, natural materials, patterns, textures, and prospect refuge are utilized far more often than greenery, water features, natural sounds and scents, biomorphic forms, or mystery and peril. This is also true of the conventional architects, who note that daylight and access to views are a given on any project, but greenery, biomorphic shapes and forms, and spatial experiences are rare. While part of this distinction may be due to both design professional and client understanding of biophilic design, this may also occur because of the culture of the design firm that the architects and designers are a part of. This can be seen as the early adopters who use biophilic design to holistically guide them are part of much smaller, self-owned design firms as compared to the early adopter consultants and conventional architects who work at mid-sized or large firms. Larger firms tend to have more projects going on at one time with stricter schedules when compared to smaller firms, which may limit biophilic design use.

Architects and designers use the three categories of biophilic design in varying frequencies. It is clear from the data that indirect experiences of nature are the most commonly used category of biophilic design. The data illuminated that this category is the easiest of the three to integrate, as designers have to specify materials to use in a space, so specifying biophilic furniture and finishes can happen with less opposition. The second most frequently used category is direct experiences of nature, particularly access to views and daylight. These are incorporated most often, while greenery, water

features, thermal variability, natural sounds, natural scents, and non-rhythmic sensory stimuli are used less frequently. Lastly, spatial/place-based experiences are less likely to be incorporated, although if they are, prospect and refuge are more commonly used when compared to mystery and peril, which are highly misunderstood.

Biophilic Design Standards

The data on the current state of biophilic design standards highlighted similarities between two standards with a biophilic design requirement. Both the Living Building Challenge and the WELL Building Standard do not require a post-occupancy evaluation to ensure that the intended plan for biophilic design was successfully carried out. Instead, the mandated requirements are qualitative and are met through a written narrative commitment to incorporate elements of biophilic design, like light, space, and place. There is no requirement to include several types of biophilic design, which would lead to a more diversified practice. The WELL Building Standard has an option for a quantitative measure of biophilic design, requiring that 1% of the floorplan be covered in greenery and that there is a water feature for every 9,290 m^2. While this specific optimization is promoting an integration of direct connections to nature, it may add to the misconception that biophilic design is only about plants, something noted multiple times in the interviews. While water features and plants are great additions to space, they are not the epitome of biophilic design, and thus more can be achieved here.

Best Practices

While the current state of biophilic design is used differently by the three groups, a set of best practices emerged from the data, both through directly asking what the best practice of biophilic design is and from emerging patterns of the early adopters and design researchers. These best practices include incorporating a multisensory, multi-element design that uses each category of biophilic design in a project. Additionally, the best practice of biophilic design from the building examples that the participants mentioned used multiple scales of biophilic design, incorporating not only the element level of biophilic design, but also floor and building scale. Incorporating biophilic design on the higher levels requires a holistic biophilic design approach, which may be why these buildings are thought of as successful examples of biophilic design. Lastly, a connection to place is considered a best practice, because it can be difficult to achieve. However, when done successfully, the result is overwhelming, creating a space that is integrated into the landscape and community, which creates a more "soulful" experience (Early Adopter D, Calabrese Architects, 2018).

Some of these best practices coincide with the best practices that the early adopters and design researchers use, which conventional architects can learn from. For example, incorporating multiple kinds of biophilic design that elicit a multisensory experience is brought up again, as these tend to be most effective at producing positive outcomes. Another best practice is thinking about biophilic design in the early phases of the design process, as this creates the ability to incorporate it throughout the entirety of the project and to use multiple scales of biophilic design. The later that biophilic

design gets incorporated, the less that designers are able to do, as the space is massed and the layout is set. The third best practice is the ability to clearly communicate outcomes associated with specific elements and to communicate these outcomes in tangible, valuable ways. The ability to monetize outcomes for clients will prompt them to invest in biophilic design. The final best practice is to use desired outcomes to drive the biophilic design strategies that are chosen. For example, instead of deciding to place a green wall in a space because of its aesthetic appeal, designers should understand what a specific space needs to achieve. Does the occupant need to feel energized and productive, calm and relaxed, or cognitively restored? Each of these outcomes require different combinations of design elements to engender these emotions and they should be thought through before choosing how to incorporate biophilic design. An outcome driven approach will be the most effective way to implement biophilic design.

4.2 Barriers to Biophilic Design Implementation

From the data, six themes of barriers to the implementation of biophilic design emerged: client-imposed barriers, a lack of knowledge and understanding, communication issues, the integrity of biophilic design, accessibility of resources, and a need for a strong value proposition. This section will address these barriers and propose solutions that have a basis in the third section of the data, on how to promote biophilic design in the future.

Client-Imposed Barriers

This category of barriers is made up of limitations associated with the clients of design professionals, and thus, are largely out of the design professional's control. Cost and maintenance efforts seemed to be the largest barriers, as clients tend to focus on reducing initial and operating costs of design projects. At the moment, biophilic design may initially cost more because of the dearth of products available. However, in time, as demand for biophilic products increases, so will supply of these products, driving price down. Additionally, the cost of biophilic design is not necessarily more than a well-designed project, as natural materials, daylight, and interesting spatial experiences are a typical part of the design process. This may be a misconception about the price of implementing biophilic design.

Maintenance seems to be a barrier, as the participants felt that their clients do not want to put in the additional effort to upkeep the plants and water features of the space. However, this responsibility does not need to be placed on the client, as there are third party organizations that offer maintenance of these installations for a fee. This takes the pressure off of the facility managers and allows for easy upkeep of biophilic features.

Another key piece to the barrier of cost and maintenance is a clear value proposition of biophilic design, to make the investment worth it. This will be discussed later in this section.

The actual space of the projects and industry trends were two other client-imposed barriers. Sometimes, the physical location of the space makes it hard to provide access to nature, especially in large cities with old buildings. The conventional

architects also felt that the program of the space, for example a workspace versus a gathering space, limits the kind of biophilic design that can be achieved. However, in both cases biophilic design can still be implemented. If a direct experience of nature cannot be implemented due to location, more indirect and spatial experiences can be included. Also, the idea that biophilic design only belongs in gathering spaces or workspaces is a misconception, as biophilic design can be incorporated into any space where a psychological, physiological, or cognitive outcome is desired. This needs to be addressed in educational resources for designers to understand, which will be discussed in further detail later in the paper.

Since the biophilic design industry is still gaining ground, there are very few examples for clients to look at and inspire demand. An industry trend may be needed for clients to begin to demand biophilic design, which can then in turn promote a new design ethos for professional architects and designers. This design ethos will focus designers on the human condition of space rather than meeting space efficiencies.

Knowledge and Understanding in Design Professionals

There seems to be a lot of misconceptions about biophilic design within the group of conventional architects. They tend to believe that biophilic design is about bringing plants into a space or including other, disparate natural elements. This is not the case, as biophilic design is an intentional process of evoking a connection to nature and natural systems. Additionally, there needs to be an overall understanding that biophilic design is focused on the human experience of space, specifically evoking connections to nature through engaging and continuous moments with biophilic

elements. To address this, as well as the lack of knowledge of how to practice biophilic design, education and the barriers that fall under accessibility will be discussed together.

There are three scales of education that can address design professional lack of understanding about biophilic design, both conceptually and in practice. The three scales are in-school learning, learning by doing, and in-person educational events.

If architecture and design professionals were educated about biophilic design during their years in college, they would have a much clearer understanding of what is and is not biophilic design. It would also, likely, reduce the number of misconceptions that conventional architects have about it. Additionally, it would allow for them to think about biophilic design earlier in the process and practice using it in school projects.

Educational programs of this nature are becoming more popular; however, many architecture and design schools do not have any courses on biophilic design. This must change if a new generation of nature-minded designers is desired. At the university scale new curricula is constantly being developed to promote new standards of design, like sustainability and universal design. If biophilic design could become a staple class in any architecture or design program, it would aid in creating this new generation of biophilically-minded design professionals. To achieve this, both current students and faculty must demand at least one course that educates about biophilic design. In addition, universities that promote research of biophilic design could generate new information about the field and create opportunities to teach their students about new discoveries.

The next scale of education, learning by doing, is also key to unlocking the potential of designers in regard to biophilic design. If conventional architects and designers worked on projects with early adapters, they would see successful applications come to fruition. They will be empowered by being a part of that process, as well as expand their capacity on how to execute successful biophilic designs. They could learn outcome driven biophilic design in a hands-on manner that they would not forget. This type of education is generally slower than in-person educational events because it is focused on honing skills and gaining a deepened understanding by moving through the entire biophilic design process. Early adopters could partner with colleges and universities to create internships so that students studying design could gain some of this experience while they are attending school.

The last scale of education, in-person educational events, are generally framed for professionals who want to continue their education. In-person events are run by third parties who can prompt professionals to think about biophilic design through design charrettes, lunch and learns, lectures, and conferences. While these in-person events are highly popular, they are generally less extensive than in-school education and learning by doing. However, they are successful at bringing awareness of new design styles to industry professionals. For a successful in-person event, conventional architects mentioned that they would like experts in the field or researchers with qualifications to run these events. Specifically, they do not want to learn about biophilic design from their carpet manufacturer or other manufacturers who are generally pitching to sell their products. They want to hear hard, convincing facts about why they should use biophilic design.

These three scales of education should aim to discuss biophilic design in a manner that is easy to understand for designers, perhaps simplifying the scientific language of biophilic design. It should also clearly discuss the holistic process of biophilic design. If professionals can be educated early, they may be more likely to create true connections to place and incorporate biophilic design earlier in the design process.

In addition to education, consolidating resources on biophilic design will augment the effort to combat lack of knowledge and understanding for conventional architects and designers. This will be discussed in the accessibility section.

Knowledge and Understanding in Multiple Stakeholder Clients

According to the interviews, client knowledge and understanding is more focused on the value of biophilic design. Many of the participants noted that if clients understood the value of biophilic design, specifically the return on investment, there would be little hesitation for them to invest in it. Since the multiple stakeholders have various goals, a value proposition that appeals to all of them is required for a design that is seen to completion. The director likely wants a space that will promote productivity and satisfaction within their employees, while the facility manager is more focused on the programmatic parts of design, and the chief financial officer is motivated to stick to the budget. If biophilic design is valued by each of these key stakeholders, it will be considered an integral part of the design project.

To encourage clients to invest in biophilic design, a new player is recommended in the design process. Generally, clients come to design professionals to

begin a project and these design professionals have a visioning session with them to understand their wants and needs. This then determines the program of the project and the rest of schematic design. However, since design professionals are not well versed in biophilic design, it rarely comes up in conversation. Thus, a new key player, a design researcher or consultant should enter the discussion when clients are still determining their concept and programming needs. This design researcher must be credible and well versed in biophilic design. They must also be able to clearly communicate a strong value proposition for the client, through both a demonstration of outcomes that they can expect to see, for example an x% increase in productivity leading to an x% increase in profit, while also making it personal to the client. Raising awareness of the client's personal connection with nature will generate a clearer understanding of the value of biophilic design, because everyone has a personal connection to it. This will then lead the client to treat biophilic elements as integral to the project rather than a special add on. The design researcher only needs to be a part of the process until the design professionals have the capacity to clearly communicate the value proposition of biophilic design on their own.

Once the client understands that biophilic design is an integral element, they can communicate that idea with all the relevant stakeholders in their company. When this is clearly communicated, all stakeholders will be on the same page. This means that whoever the design professionals talk to, whether it be the director, facility manager, or chief financial officer, they will help them bring their design to fruition, rather than removing biophilic elements due to misunderstandings and miscommunication.

Accessibility of Resources

The data demonstrated that, while resources exist, they are not yet accessible to design professionals due to their language, how they are presented, and how they are disseminated. To solve these issues, a consolidation of the resources is vital. A database or a website that hosts all the information about biophilic design would be a key tool to ensure that all designers have the necessary resources for practice. For example, a website that can direct users to Terrapin Bright Green's 14 Patterns of Biophilic design, Stephen Kellert's Principles of Biophilic Design, and successful case studies would be extremely useful. The resources should understand that architects and designers are their audience. Thus, strong visuals, graphic design, and a toned-down scientific language is necessary to capture the audience's attention. Additionally, if it contained a list of manufacturers that make biophilic products, then it would educate designers about available products and aid them in selling these products to clients. This database could be created by the organizations that are driving biophilic design research and use, such as Terrapin Bright Green, the International Living Future Institute, Interface, and the International WELL Building Institute, to name a few. They could hold a conference and try to consolidate their resources, create a shared database, and determine how to present this information by working to solidify the diverse language surrounding biophilic design into one specific vernacular.

Successful applications, such as case studies and awards, should be represented in the media of the architecture and design world. This could be through articles in architecture and design magazines, a blog on a popular website, or a magazine focused

on biophilic design. Marketing successful applications in this manner will create a desire for design professionals to practice biophilic design.

Value Proposition

Many of the respondents thought that a strong value proposition is still a barrier to the practice and demand of biophilic design. However, this barrier can be solved through more research, a clear narrative, and creating a new normal for industry standards.

It was clear from the data that more research is needed to truly understand the value of biophilic design. The nature of the research currently available lacks robustness in methodology, as most research is a field study that focuses on a short exposure to nature. This type of methodology is associated with less credibility because external and internal validity is weak. Future research on biophilic design should be longitudinal, as it is thought that the effects present themselves over a continuous interaction with nature and natural elements. Additionally, researchers should focus on tangible outcomes, such as how stress is being reduced, what the effect on worker productivity and satisfaction is, and how these beneficial outcomes impact profit. This can be accomplished through experimental studies as well as pre/post occupancy evaluations. The more the research on this topic is focused on quantitative aspects, the more impactful they will be for clients and design professionals. This research should be conducted both by companies with a strong commitment to biophilic design, like those mentioned above, but also by any design firm that uses biophilic design in their projects. Design firms are beginning to conduct

more post-occupancy evaluations to prove the value of their work. If they could do so for their biophilic projects, they would contribute data that proves their firm's value in addition to the value of this type of design. Any new research that companies conduct must be added to the aforementioned database of resources.

Communication of these outcomes in a clear, engaging manner is also important to the value proposition. As mentioned before, if a design researcher can address a client and clearly communicate this tangible value, then clients will be more open to investing in it. This should be coupled with a personal narrative to help them understand their own connection to nature and the importance nature holds for every individual. If biophilic design is invested in, it will raise awareness in other people, which in turn will allow more people to understand its value for themselves.

Lastly, if biophilic design could become a new industry trend, it would create demand from clients. Sometimes, something larger than education is needed to promote a new type of design. Education can be timely, however, the faster that biophilic design is adopted, the better our buildings will be. Although it can be seen as watering down the integrity of biophilic design, creating a trend will generate excitement about it. This will then produce more buildings that include biophilic elements, as well as more successful examples and case studies. This can then drive the state of biophilic design further to meet the more holistic biophilic design approach that the early adopters use. One participant mentioned that getting biophilic design incorporated into the Leadership in Energy and Environmental Design (LEED) standard would bring it to the forefront of the design industry. This is because LEED is already an accepted certification system with a huge customer base. While the

Living Building Challenge and the WELL Building Standard have more stringent requirements, they are less well-known and thus, the uptake is slower. If biophilic design were incorporated into LEED, it would create more awareness of biophilic design, which may then drive clients to the other, more stringent standards.

4.3 The Ideal Biophilic Design Process

If all these barriers could be addressed, an ideal biophilic design process could be achieved, as shown in Figure 4.1. Through more research by design firms and companies with a mission for biophilic design, a consolidation of resources, and successful marketing, a trend of biophilic design will emerge in the industry. Clients will then come to design firms with a desired project, after seeing this trend. The design professionals and clients will meet and discuss their concept and needs. A design researcher will join this conversation and note how biophilic design could help the space achieve outcomes like productivity, health and wellness, and satisfaction. These outcomes will be clearly quantified and communicated based on the new, more credible research. Additionally, they will frame the value of biophilic design in a personal nature, so that the client realizes that biophilic design is an integral part of the process and not seen as an add on. This will be communicated to all stakeholders so that it is not removed from the project down the line. Once biophilic design is seen as integral, design professionals will begin thinking about it earlier in the design process as a driving principle. These professionals could go to a database where the resources about biophilic design are consolidated, visually appealing, and easy to read. In this database, case studies for specific industries will be clearly highlighted and easy to

understand. Using these resources as inspiration, designers can then create an effective biophilic design strategy, which in turn will create a successful application. A pre/post occupancy evaluation will be conducted throughout the process, thus generating more data and case studies about successful, and potentially unsuccessful, biophilic designs which future users can learn from. Through this process, designers will gain hands on experience and hone their skills, so that they can improve their biophilic design skills for the next time they need to use them.

Although this is the ideal, there are many steps to take before the process becomes this holistic. Although there are two perspectives on biophilic design, one being that it must be fully intentional and a driving force of decisions and the other being an innate integration of biophilic elements, there is a middle ground to be found. If conventional architects take smaller steps to integrate biophilic design more holistically, such as considering more floor or building level applications, then over time it will become part of their process. Until then, there should be an outcome-based approach that focuses on what specific human outcome the project desires and implementing biophilic design elements accordingly. It can still come up in the later phases, for now, but it must be well thought out in order to be successful. Over time, this will be incorporated earlier and become a driving principle.

The Ideal Biophilic Design Process

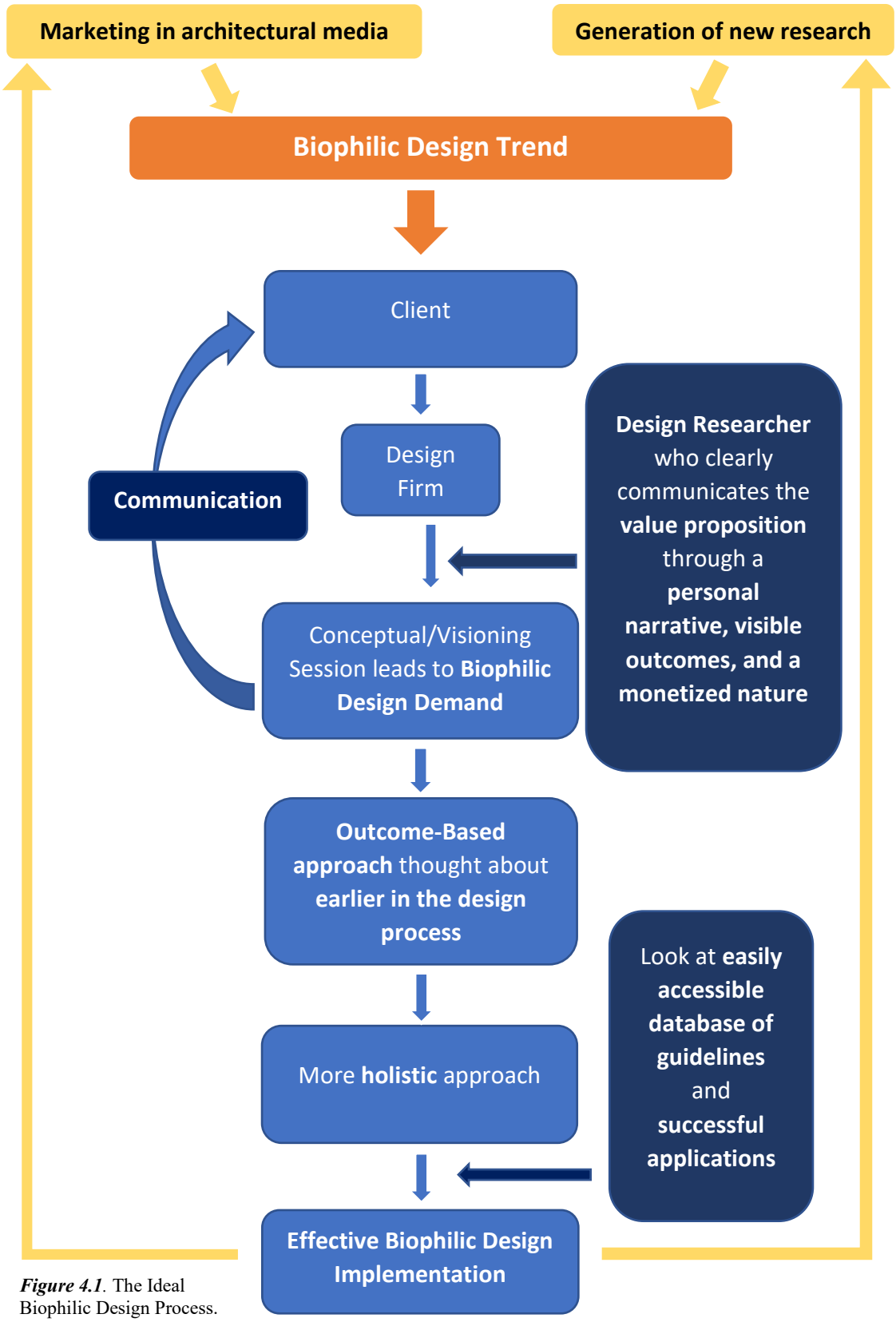

Figure 4.1. The Ideal Biophilic Design Process.

5. Conclusion

This thesis aimed to explore the current practice of biophilic design and understand the barriers to implementing a multisensory, multiple element biophilic design solution. Through qualitative, semi-structured interviews with three groups of participants, early adopters of biophilic design, conventional architects and designers, and design researchers who create standards of biophilic design, the current state of biophilic design, the barriers to it, and solutions to promote it in the future were revealed.

The process demonstrated that client-imposed limitations, a lack of knowledge and understanding, communication issues, lack of accessibility, the integrity of biophilic design, and a lack of a value proposition are the largest barriers to adoption. To mitigate these barriers and achieve the ideal biophilic design process, there is a distinct need for education at all three scales, consolidation of resources in one location, which are aesthetically appealing and framed in a way that are easy to understand, research with high external validity that demonstrates the visible outcomes of biophilic design, and a design research consultant that can clearly communicate these outcomes to clients in order to prove the value of biophilic design.

It is also clear that education is not only solution to these barriers and is a timely process, so progress will be slow. To bring biophilic design to the forefront of the design world, there must be an acceptance of smaller steps and trends that bring the industry closer to true biophilic design. Although biophilic design is a guiding design ethos, the innate use of biophilic design should not be scolded. In fact, if this innate use can be bolstered through an outcome-driven design process, then the design

world will see a higher level of biophilic design come to fruition. This approach, coupled with stringent standards, such as the Living Building Challenge and the WELL Building Standard, as well as experts who set the gold standard for what biophilic design can be, will drive the industry to meet the ultimate goal of an intentional, holistic biophilic design process that is practiced universally.

This thesis also validated that interviews with three key groups of informants, early adopters of the practice, conventional professionals, and researchers of the practice, can be a powerful tool to understand barriers to the adoption of new technology and design in the building sector. This method can inform the future study of adoption by identifying best practices of the current state, understanding how the conventional professionals understand and use the practice, determining barriers to adoption, and understanding how research can move the field forward. This tool can identify barriers to adoption earlier in the process and generate an understanding of how to address these barriers in the future, hopefully leading to quicker adoption.

5.1 Limitations and Future Research

As this was an exploratory thesis, it did have its limitations. Due to the small sample size, the results of this thesis may not be generalizable to the entire population of early adopters, conventional architects, and design researchers. Additionally, since most of the respondents were from the North East of the United States, results may have been skewed to address the design practice in America and thus, this may not be generalizable to international architects and designers. Due to timely nature of the project, convenience samples were largely used, which means that many of the

respondents attended Cornell University at one point or another. This may have skewed the results because they come from the same educational background.

In the future, research should be done that minimizes these biases. A larger, more diverse sample would produce more generalizable results. Future research should also address the largest barriers for clients, as this thesis was in the perspective of design professionals. If research can understand the barriers to implementing biophilic design in practice and the barriers to demanding biophilic design in clients, then the major stakeholders will be accounted for. Research should also be conducted on the type of outcomes that clients care most about in order to create a strong and clear value proposition. These studies will move the field of biophilic design forward and increase the adoption of the design principle.

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APPENDIX A: INTERVIEW SCRIPT AND DEVELOPMENT

	Architects and Designers	
Number	**Question**	**Source**
1	What is your name?	Julie Gordonson
2	Please tell me a little bit about the company that you work for.	Julie Gordonson
3	What is your position at this company?	Julie Gordonson
4	Have you heard of biophilia or biophilic design?	(Kirk, Siversten, Petersen, Nilsen, & Petersen, 2016)
5	Can you define biophilic design in your own terms?	(Weatherson, McKay, Gainforth, & Jung, 2017),
6	Do you think that biophilic design is or is not valuable to the design field?	(Kirk et al., 2016)
7	Can you give me an example of what you think the best practice of biophilic design (building or space) is?	Julie Gordonson
8	Do you use biophilic design in practice?	(Moore, Britten, Lydahl, Naldemirici, Elam, & Wolf, 2017)
9	What percentage of your total projects would you say you use biophilic design in?	Julie Gordonson
10	Can you explain when biophilic design is brought up in the design process?	Julie Gordonson
11	Do clients ever request biophilic design or designs that evoke nature?	Julie Gordonson
12	Knowing the industry, would the onus be on you to bring up biophilic design in discussion with clients? Explain how you would tell a client about it.	(Moore et al., 2017)
	Direct experience of nature, also known as nature in space, involves a direct and physical connection to nature in an indoor environment. For example, the design strategy may be visual (access to windows, indoor plants) and non-visual (water features, natural sounds, dynamic lighting, and thermal variability).	Julie Gordonson
13	Have you ever used this category of biophilic design? Can you give an example?	Julie Gordonson
14	What percentage of your projects use this category?	Julie Gordonson

15	Can you identify any barriers to using this category?	Julie Gordonson
	Indirect experience of nature, also known as natural analogues, refers to an indirect connection to nature. This includes colors, forms, textures, patterns, and sequences that are found in nature. For example, biomorphic forms and patterns, materials that evoke a natural environment, and visual representations of nature, like pictures.	
16	Have you ever used this category of biophilic design? Can you give an example?	Julie Gordonson
17	What percentage of your projects use this category?	Julie Gordonson
18	Can you identify any barriers to using this category?	Julie Gordonson
	Spatial experiences, also known as nature of space, refers to spatial configurations found in nature. Humans evolved to have preferences for certain kinds of arrangements, such as those that allow us to see beyond our surroundings (prospect), evoke the unknown (mystery), provide safety (refuge), and produce a fear response (peril).	
19	Have you ever used this category of biophilic design? Can you give an example?	Julie Gordonson
20	What percentage of your projects use this category?	Julie Gordonson
21	Can you identify any barriers to using this category?	Julie Gordonson
22	Out of the three categories, which do you use most?	Julie Gordonson
23	Which do you use least?	Julie Gordonson
24	What would influence you to use more biophilic design elements?	Julie Gordonson
25	Do you know of any research or resources on this topic that you suggest to clients or look at yourself?	Julie Gordonson
26	What would you like to see more of?	(Weatherson et al., 2017),
27	What do you think the largest barriers are to implementing diverse strategies of biophilic design?	Julie Gordonson
28	Do you see yourself as an advocate for promoting biophilic design?	(Kirk et al., 2016)
29	What would be the best way to promote biophilic design to other professionals? And clients?	(Kirk et al., 2016)
30	Do you have any questions for me? Is there anything else that you would like to mention about biophilic design?	Julie Gordonson

	Design Researchers	
Number	**Question**	**Source**
1	What is your name?	Julie Gordonson
2	Please tell me a little bit about the company that you work for.	Julie Gordonson
3	What is your position at this company?	Julie Gordonson
4	Have you heard of biophilia or biophilic design?	(Kirk et al., 2016)
5	Can you define biophilic design in your own terms?	(Weatherson et al., 2017),
6	Do you think that biophilic design is or is not valuable to the design field?	(Kirk et al., 2016)
7	Can you give me an example of what you think the best practice of biophilic design (building or space) is?	Julie Gordonson
8	Can you explain the process of developing design standards?	Julie Gordonson
9	How large is the focus of biophilia during the development of these standards?	Julie Gordonson
10	Can you explain the process of translating research for design professionals?	Julie Gordonson
11	Do you think that there is any research regarding biophilic design that is missing?	Julie Gordonson
12	What is the typical process of a project pursuing your certification?	Julie Gordonson
13	Do you ever encourage certain patterns related to biophilia over others in your guideline?	Julie Gordonson
14	Who uses your guidelines? How do you think they are using them?	Julie Gordonson
15	Have you ever received feedback from users about your guidelines?	Julie Gordonson
16	How far spread do you think your communication reach is? Do you ever reach design clients themselves?	Julie Gordonson
17	How often do you think the average designer uses research?	Julie Gordonson
18	Do you ever hold workshops, design charrettes, or other educational programs to teach designers about biophilic design?	Julie Gordonson
	Direct experience of nature, also known as nature in space, involves a direct and physical connection	

	to nature in an indoor environment. For example, the design strategy may be visual (access to windows, indoor plants) and non-visual (water features, natural sounds, dynamic lighting, and thermal variability).	
19	How often (in percentages) do you think this strategy is implemented in building design? Why?	Julie Gordonson
20	Can you think of ways to incentivize this category of biophilic design?	Julie Gordonson
	Indirect experience of nature, also known as natural analogues, refers to an indirect connection to nature. This includes colors, forms, textures, patterns, and sequences that are found in nature. For example, biomorphic forms and patterns, materials that evoke a natural environment, and visual representations of nature, like pictures.	
21	How often (in percentages) do you think this strategy is implemented in building design? Why?	Julie Gordonson
22	Can you think of ways to incentivize this category of biophilic design?	Julie Gordonson
	Spatial experiences, also known as nature of space, refers to spatial configurations found in nature. Humans evolved to have preferences for certain kinds of arrangements, such as those that allow us to see beyond our surroundings (prospect), evoke the unknown (mystery), provide safety (refuge), and produce a fear response (peril).	
23	How often (in percentages) do you think this strategy is implemented in building design? Why?	Julie Gordonson
24	Can you think of ways to incentivize this category of biophilic design?	Julie Gordonson
25	Can you think of ways to attract clients to use combinations of biophilic design patterns?	Julie Gordonson
26	What do you think the largest barriers are to implementing diverse strategies of biophilic design?	Julie Gordonson
27	Do you have any questions for me? Is there anything else that you would like to mention about biophilic design?	Julie Gordonson

APPENDIX B: EMAIL TO RECRUIT EARLY ADOPTERS AND CONVENTIONAL ARCHITECTS

Subject: Cornell Research on Biophilic Design

Dear Mr./Ms. _____

I am currently a master's student at Cornell University, working on a thesis on biophilic design. More specifically, I am studying how to diversify the practice of biophilic design strategies. I wanted to get in touch to ask about your interest in supporting my research on biophilic design practice.

To briefly introduce my research, the question that I am exploring is, how can biophilic design best be applied to improve human health and environmental quality? As part of my research, I am conducting interviews with professionals in the field of design and architecture on their opinions of biophilic design in practice, how they use it, and if they see any barriers to it.

The resulting product from this will be a framework, discussing how to diversify biophilic design strategies in order to promote them more effectively in practice for multiple stakeholders. I would be happy to share this with you when my research is complete in August.

I was hoping to request a casual interview conversation with you or another member in your team on your perspective of biophilic design practice. I would greatly appreciate your support and would love to discuss further about the possibility. Please let me know if I should forward my request to another staff member at _____.

I really hope that you are interested in supporting my research. Feel free to e-mail me back with any questions regarding my study. Thank you very much for all your time and consideration. I look forward to hearing back from you.

Thank you!

Sincerely,
Julie Gordonson

APPENDIX C: EMAIL TO RECRUIT DESIGN RESEARCHERS

Subject: Cornell Research on Biophilic Design

Dear Mr./Ms._____

My name is Julie Gordonson and I am currently a master's student at Cornell University. I am working on a thesis on biophilic design, and more specifically, how to diversify the practice of biophilic design strategies. I wanted to get in touch to ask about your interest in supporting my research on biophilic design practice.

To briefly introduce my research, the question that I am exploring is, how can biophilic design best be applied to improve human health and environmental quality? As part of my research, I am conducting interviews with professionals in the field of design and architecture, as well design researchers who create standards and guidelines of biophilic design. The interview is focused on their opinions of biophilic design in practice, how they use it, and if they see any barriers to it.

The resulting product would be a framework, discussing how to diversify biophilic design strategies in order to promote them more effectively in practice for multiple stakeholders. I would be happy to share this with you when my research is complete in August.

I was hoping to request a casual interview conversation with you or another member in your team on your perspective of biophilic design practice. The interview should last 25-30 minutes. I would greatly appreciate your support and would love to discuss further about the possibility. Please let me know if I should forward my request to another staff member at _____.

I really hope that you are interested in supporting my research. Feel free to e-mail me back with any questions regarding my study. Thank you very much for all your time and consideration. I look forward to hearing back from you.

Thank you!

Sincerely,

Julie Gordonson